Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

SEPTEMBER, 1953

TECHNOLOGY DEPT.

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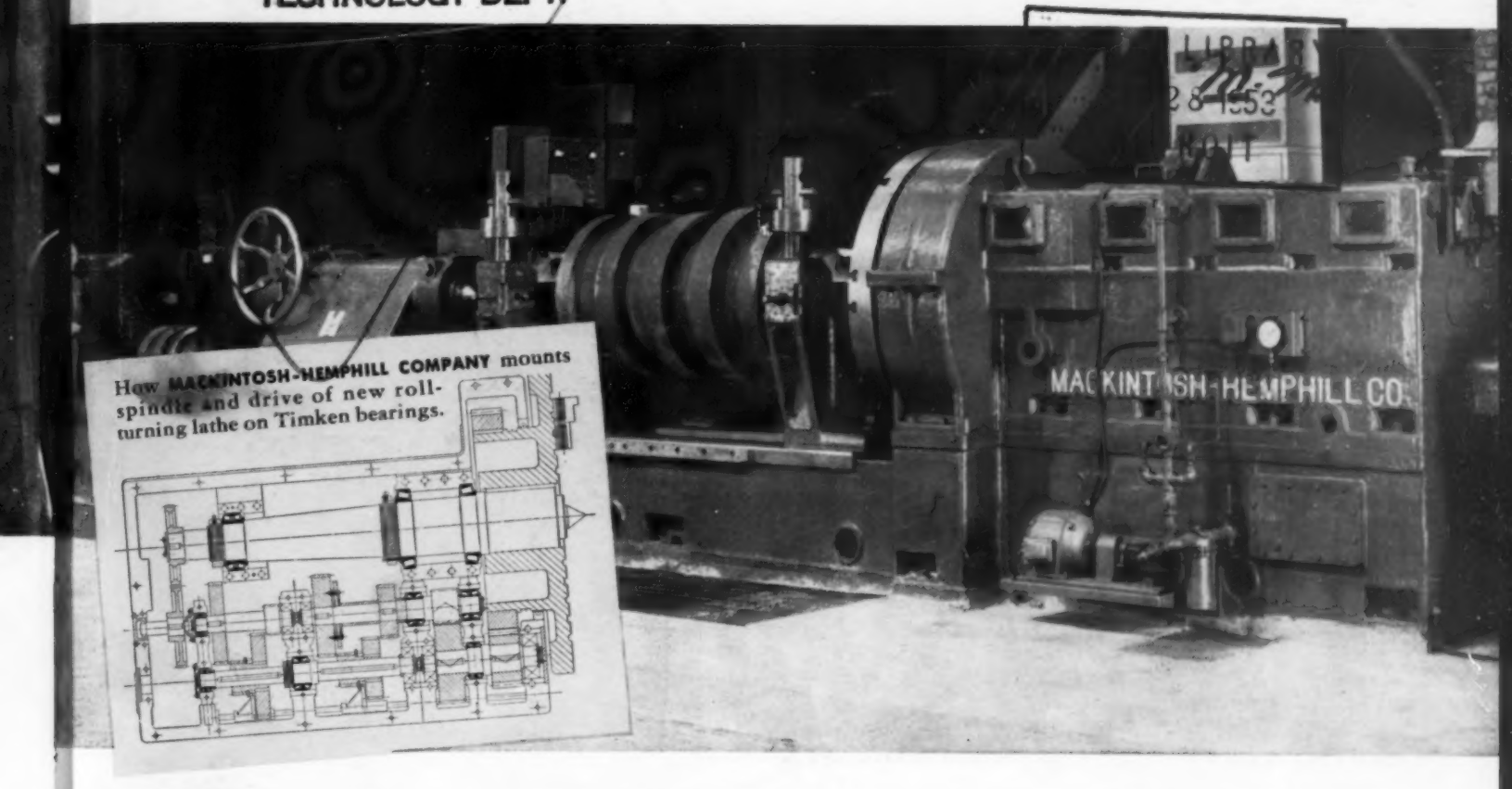

How MACKINTOSH-HEMPHILL COMPANY mounts spindle and drive of new roll-turning lathe on Timken bearings.
MACKINTOSH-HEMPHILL CO.

Roll necks get electronic shave—and a close one—*with help of TIMKEN® bearings*

THIS giant Mackintosh-Hemphill roll-turning lathe at a large eastern steel mill is expected to save as much as 75% in actual roughing and finishing time. All-electronic controls guide the cutting tool in automatically reproducing the complex roll neck and roll body outlines.

While the necks are being contoured, the roll turns on live centers. The drive end center in the main spindle is mounted on two oversize Timken® bearings at the work end, a smaller two-row Timken bearing at the other end. With line contact between rollers and races, these bearings handle 35-ton rolls with ease. The tapered roller design eliminates both end and side play, and runout on these Timken bearings never exceeds .0003".

The importance of this last is seen from the fact that, while the body is being turned, the roll is supported on its necks. Hence, the accuracy of the Timken bearings used in contouring the necks is reflected in the accuracy of the entire roll!

For technical information and assistance on bearings for steel mill equipment, consult the Timken Company engineering department. Always look for the trade-mark "Timken". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

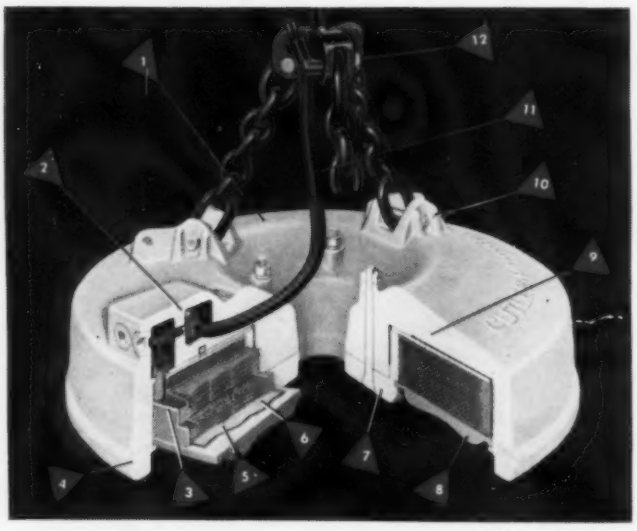
NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ↓ AND THRUST →○← LOADS OR ANY COMBINATION →✳←

INSIDE AND OUT, CUTLER-HAMMER MAGNETS ARE

BUILT TO LIFT BUILT TO LAST

Check any and every feature of Cutler-Hammer Magnet construction and you will find these magnets are built to lift, built to last. From the strap copper windings that give the coils greatest cross-section area of copper to the high permeability steel spool on which the coils are wound, this is true. From the asbestos ribbons, and the bonded mica insulation between the coils, to the heavy dynamo steel body, this is so. From the double-celled moisture-proof terminal box to the engineered yoke design that keeps chains from excessive wearing, this is evident. In every way, Supermagnets are built to lift more each trip, to pick up and discharge loads faster, to maintain capacity and speed all day long and through the long magnet life.

You will find experienced men of the iron and steel industry in full agreement. You *should* have a Cutler-Hammer Supermagnet. CUTLER-HAMMER, Inc., 1257 St. Paul Avenue, Milwaukee 1, Wisconsin.



1. Rugged, cast, high permeability dynamo steel body.
2. Coil connections in water-tight compartment. Leads readily renewed.
4. Tough alloy steel outer pole shoe welded to body.
3, 5 & 6. Strap copper wound coil, asbestos-ribbon insulation between turns, vacuum impregnated with high temperature thermal setting compound. Bonded mica insulating sheets between windings.
7. Bolted inner pole shoe, easily replaceable.
8. Heavy manganese steel shield protects coils from shock.
9. Steel sheathed capsule coil can readily be replaced.
10. Integrally cast suspension lugs stand severe service.
11. Heavy double conductor cable leads protected by heavy hose—with C-H weatherproof connectors.
12. New yoke design keeps chain strands from twisting, reduces wear of links, lengthens chain life.

CUTLER-HAMMER
LIFTING MAGNET
C-H

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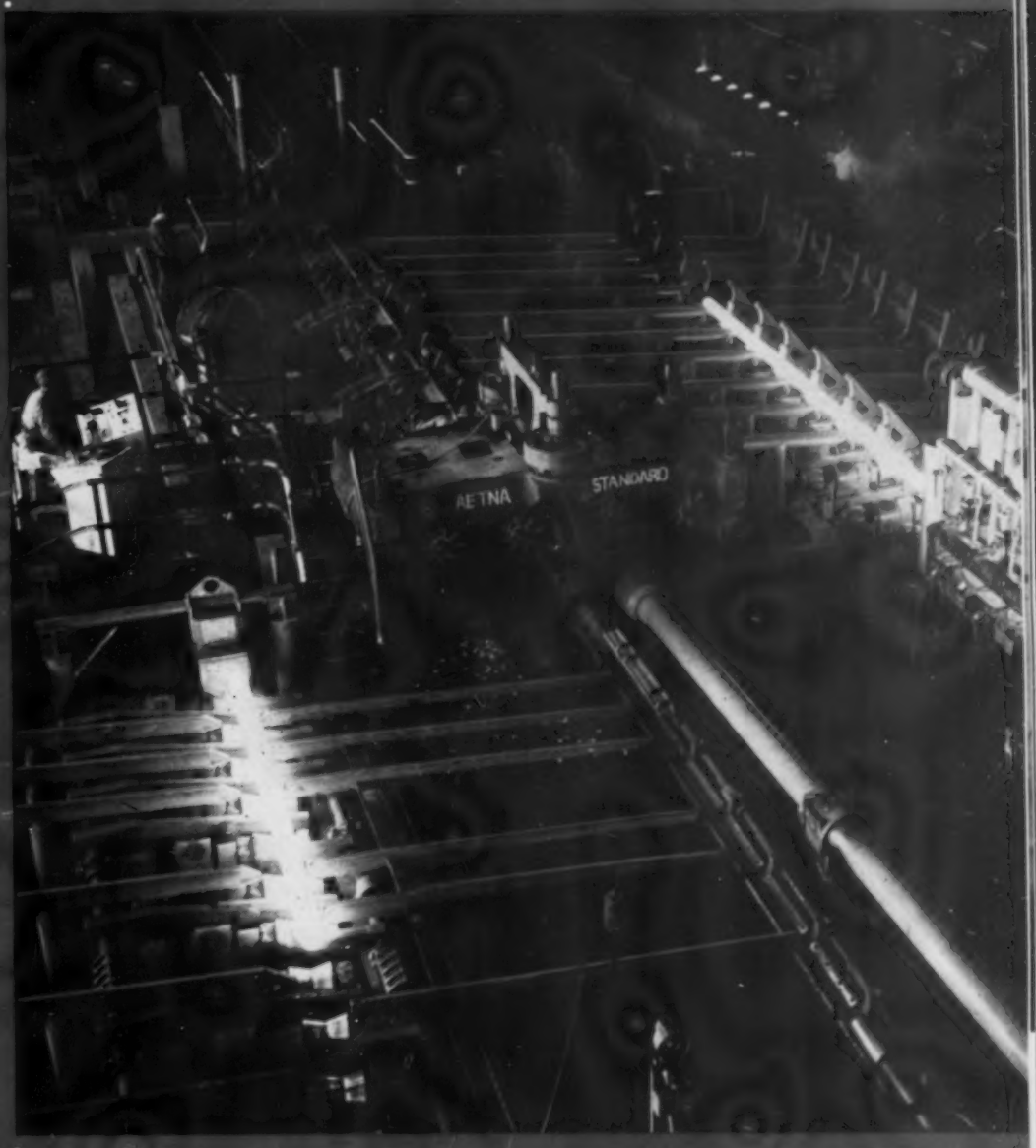
seamless tube mills

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

When a company considers an investment of the size and scope of a seamless tube mill, they can only consider a manufacturer which has facilities, experience, integrity and financial stability. The name Aetna-Standard appears in the majority of the world's tube producers today. Recent installations include two mills for sizes 2⅜" to 9⅝" to produce oil country and mechanical tubing; three (assel type) for production of bearing tubing.

Aetna makes mills to produce seamless tubing in lengths of 50 feet and a complete diameter range between 1½" to 26".



THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Aetna-Standard

PLANTS IN WARREN, OHIO • ELLWOOD CITY, PENNSYLVANIA

ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England — Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.

Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.

M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.

Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.

Damag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.

Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.

Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.

Hale & Kullgren, Inc., Akron, Ohio — Representatives for the Rubber Industry.

Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries

Cities Service Cutting Oils Proved The Very Best By Micrometer Test!

CUTTER MEASURED WITH MICROMETER. As a final test, Automatic Pencil Sharpener measures each cutter with a micrometer. All tests proved that Cities Service cutting oil was absolutely tops for this really tough job.

STRICT SPECIFICATIONS REQUIRE FINEST CUTTING OIL. APSCO Sharpeners offer many more features than other brands. To produce their top quality product, Spengler-Loomis relies on top-quality lubrication products . . . Cities Service Products, famous throughout industry.

ONLY .005 INCHES BURR OR BUILD-UP ALLOWED IN FIFTY-HOUR OPERATION CUTTING GROOVE IN B1112 STEEL!

Says Mr. C. J. Kostrzewa, Plant Superintendent: "Cutting oil requirements in our Automatic Pencil Sharpener Division are tough. To find the right coolant, we called for, and tested, samples from various companies. Over a period of testing time, we used graphs, charts and tables, keeping a running record on all coolants. As a final test, we measured the cutter with a micrometer before and after milling. The cutting oil that came out tops was Cities Service.

"I'd also like to point out that the Cities Service Engineering staff co-operated fully by offering helpful advice and excellent service."

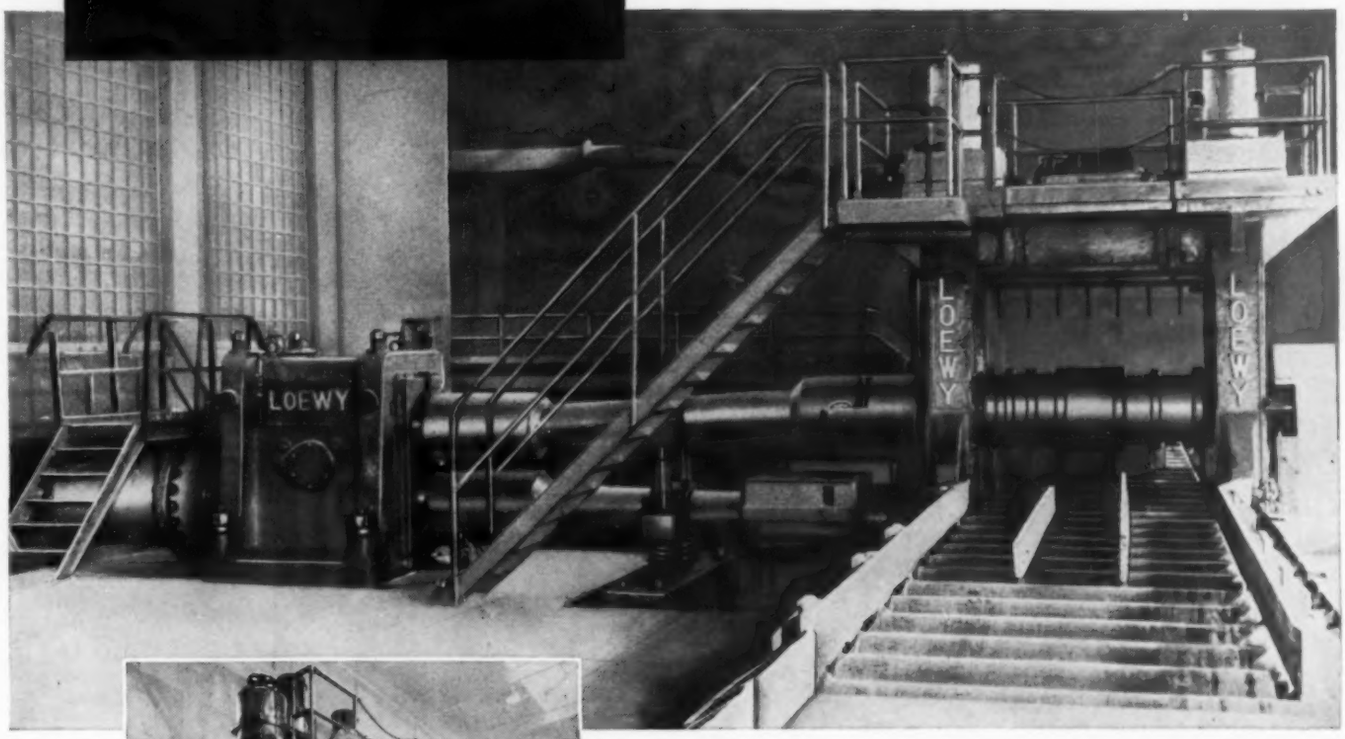
Why not discuss your lubrication problems with a Cities Service lubrication engineer? Write Cities Service Oil Company, Dept. 111, Sixty Wall Tower, New York 5, New York—or contact your nearest Cities Service office.

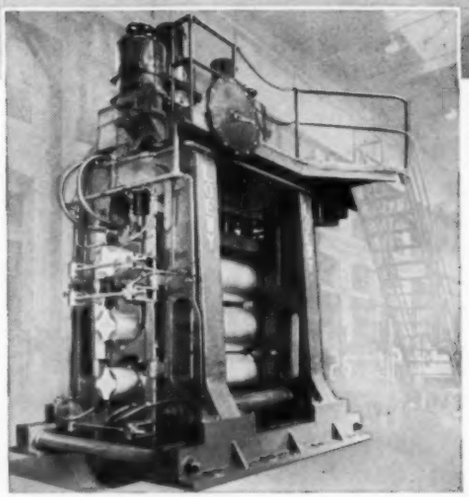
CITIES SERVICE
QUALITY PETROLEUM PRODUCTS

WE BUILD COMPLETE ROLLING MILL INSTALLATIONS

- Hot and cold Rolling Mills for ferrous and non-ferrous metals and auxiliary machinery such as Shears, Levellers, Straighteners, Coilers, etc.
- Extrusion plants for steel and non-ferrous metals
- Forging and Die Forging Plants
- Deep drawing single and double acting Presses
- Die Casting Machines for Aluminum and Brass

Below:
26" Two-high Blooming Mill, part of a complete Blooming, Slabbing, Structural and Strip Mill Installation.





Left:
26" Three-high Blooming Mill Stand, part of a complete Blooming, Slabbing, Structural, Wire Rod and Strip Mill.

LOEWY-HYDROPRESS HL NEW YORK, N.Y.

ROLLING MILL DIVISION

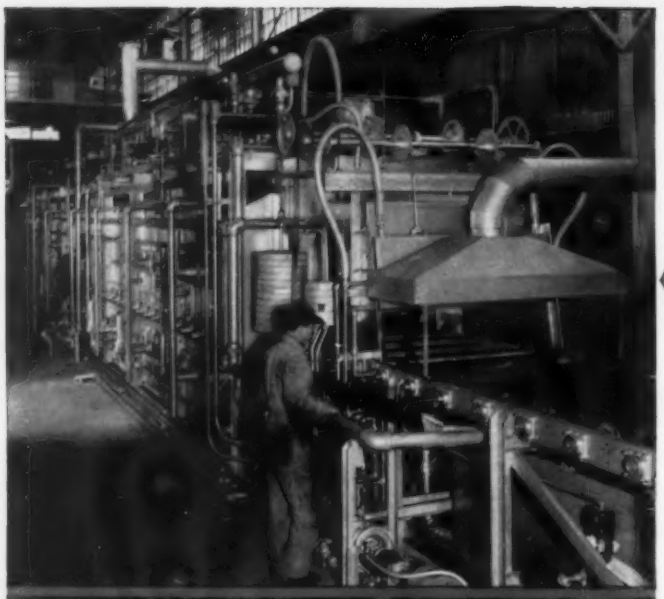
HYDROPRESS INC.

ENGINEERS • CONTRACTORS

Rolling Mills • Hydraulic Presses • Pipe Testing Machines • Special Pipe Mill Equipment • Accumulators • Pumps • Die Casting Machines

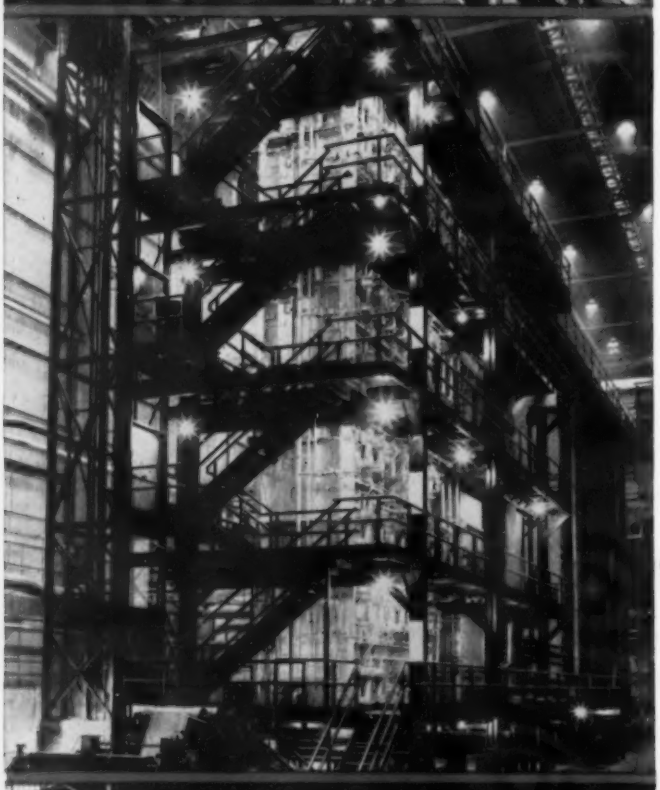
350-G Fifth Avenue, NEW YORK 1, N. Y.

BIRMINGHAM • CHICAGO • CLEVELAND • DETROIT • LOS ANGELES • PHOENIX • SAN FRANCISCO • SEATTLE • WASHINGTON, D. C. • WHEELING
GENOA, ITALY • LONDON, ENGLAND • MADRID, SPAIN • MANILA, P. I. • PARIS, FRANCE • TOKYO, JAPAN



Surface

The first continuous carbon restoration annealing of steel was carried out in this Surface roller hearth furnace. Enriched RX atmosphere is the recarburizing medium; NX atmosphere is for surface protection.



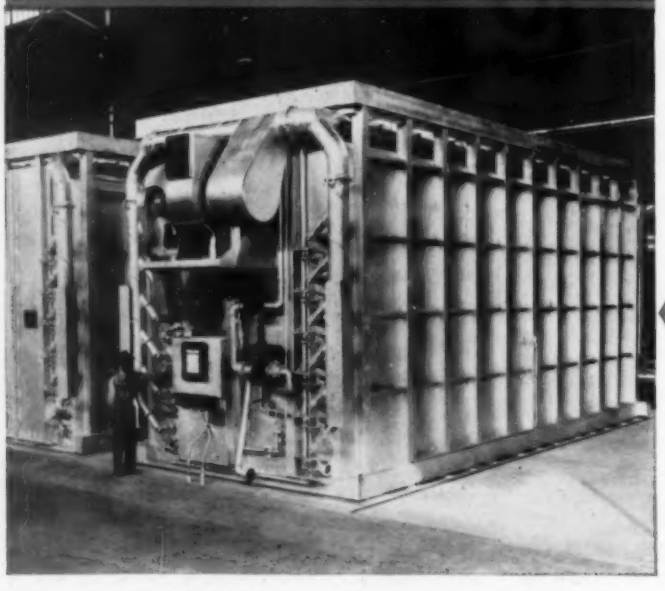
Surface

This is a Surface HNX Generator — one of the many types of generators which Surface Combustion supplies to help the industry deliver better finished steel.

SALES TOOL

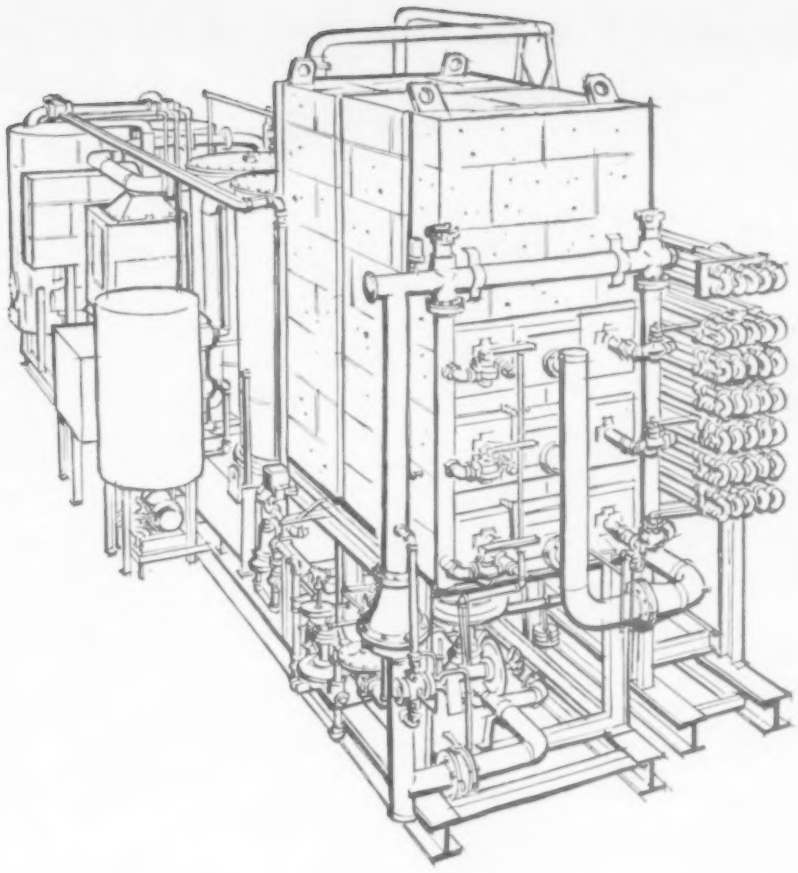
Surface

This vertical strand furnace is used for continuous bright annealing of strip for tin plating. Either NX or HNX gas can be used for the prepared atmosphere.



Batch bright annealing coiled strip is carried out in these lift type cover furnaces. This installation uses NX protective atmosphere.

Surface



ON THE MILL FLOOR

New markets open and customers are retained by developments on the mill floor. Steel surface quality, a major factor in customer acceptance, can be economically controlled through prepared atmospheres.

Many steelmakers have eliminated discoloration, "decarb," scale and other surface defects by using Surface Combustion prepared atmospheres. They have improved quality control, cut finishing costs by carbon correction and bright annealing, continuous or batch . . . clean hardening . . . clean annealing for galvanizing or tin plating.

Their customers know that this steel means lower tool and die costs, fewer rejects — more steel, in effect, for their dollar.

'Surface' builds many types of atmosphere generators, including RX, DX, NX, HNX, and AX generators for the steel industry. Literature Group S53-3 will show you how to get the right atmosphere for satisfied customers and new markets.

Surface
STEEL MILL FURNACES

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

One-way fired soaking pits • Billet reheating furnaces • Slab heating furnaces • Continuous type, controlled atmosphere strip annealing and normalizing furnaces • Controlled atmosphere annealing covers for wire and rod • Controlled atmosphere annealing covers for coil and sheets • Continuous furnaces for heat treatment of steel plate • Controlled atmosphere furnaces for carbon correction in high alloy rod and bar stock • Continuous type bright annealing and normalizing furnaces • Prepared gas atmosphere generating equipment • Pit type convection furnaces for rod annealing • Stress relief furnaces • Wire patenting furnaces

Johns-Manville announces the development of new **SIL-O-CEL 16L** *Insulating Fire Brick...*

Lompoc, California, where Johns-Manville mines and processes diatomaceous silica insulating materials

Combines outstanding physical and thermal properties for furnace service to 1600F

Check these properties of SIL-O-CEL 16L

Maximum service temperature	1600F, back-up or exposed
Approximate density	33-35 lb per cu ft
Transverse strength	60 psi
Cold crushing strength	350 psi
Linear shrinkage	0.7 percent at 1600F
Reversible thermal expansion	less than 0.1 percent at 1600F
Thermal conductivity (Btu in. per sq ft per F per hr at indicated mean temperatures)	0.92 at 500F 1.07 at 1000F 1.22 at 1500F

1—has less than 0.1% reversible thermal expansion at 1600F

2—provides high load-bearing strength

3—for direct exposure or back-up service

Here is a new development of Johns-Manville insulation and refractory research. Its exceptional characteristics provide important savings in furnace construction. Made of diatomaceous silica, Sil-O-Cel* 16L Insulating Brick is light in weight . . . has low thermal conductivity . . . high structural strength. And where furnace linings are subjected to severe heat shock or where high load-bearing properties are needed, Sil-O-Cel 16L offers outstanding performance.

Sil-O-Cel 16L is now available. Samples will be sent on request. Also available without obligation is Booklet IN-115A, which describes Sil-O-Cel 16L and other J-M Insulating Brick and Insulating Fire Brick for service to 3000F. Write Johns-Manville, Box 60, New York 16, N.Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

*Sil-O-Cel is a Johns-Manville registered trade mark

Replaces SIL-O-CEL Natural Brick

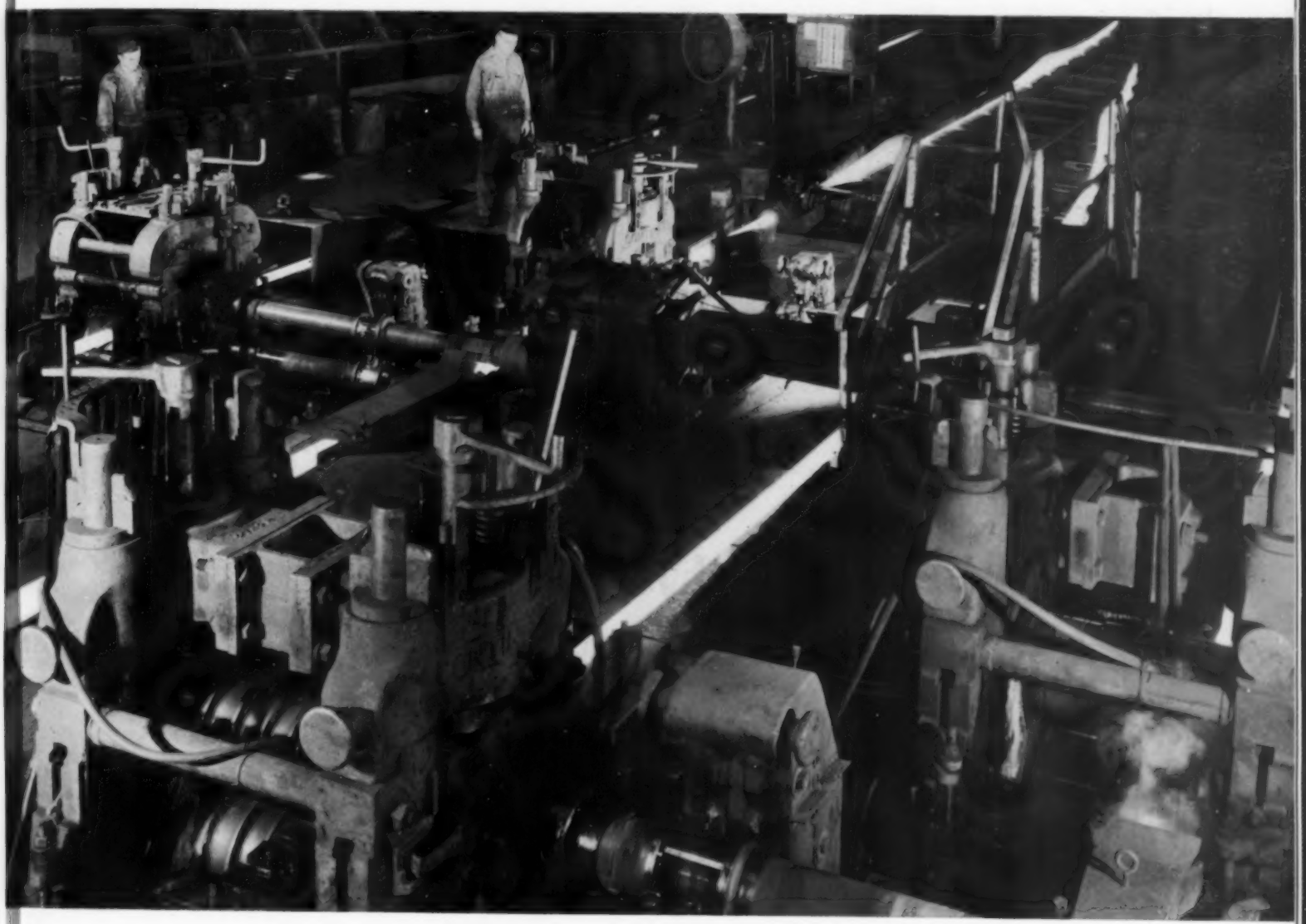
The development of Sil-O-Cel 16L Insulating Brick has resulted in the discontinuance of Sil-O-Cel Natural Brick. The outstanding properties of Sil-O-Cel 16L make it the ideal replacement for Sil-O-Cel Natural Brick for back-up use. In addition, the properties of Sil-O-Cel 16L Brick extend its use to exposed service applications.

Johns-Manville *FIRST IN* INSULATION

MATERIALS · ENGINEERING · APPLICATION

CONTINENTAL

CROSS COUNTRY MERCHANT MILL



Complete Rolling Mill Installations

SLABBING MILLS
UNIVERSAL MILLS
PLATE MILLS
HOT STRIP MILLS
COLD STRIP MILLS
TEMPER MILLS

Mills complete with Auxiliary Equipment

★ ★ ★

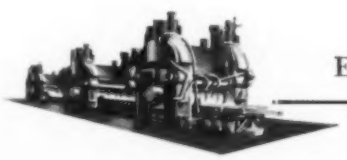
CONTINENTAL CHIPPER
ROLL LATHES
SPECIAL MACHINERY

BLOOMING MILLS
STRUCTURAL MILLS
RAIL MILLS
BILLET MILLS
ROD MILLS
MERCHANT MILLS

CASTINGS—carbon and alloy steel from 20 to 250,000 pounds

ROLLS—iron, alloy iron and steel rolls for all types of rolling mills

WELDMENTS—fabricated steel plate, or cast-weld design.



Plants at
East Chicago, Ind. • Wheeling, W. Va. • Pittsburgh, Pa.

CHICAGO • PITTSBURGH

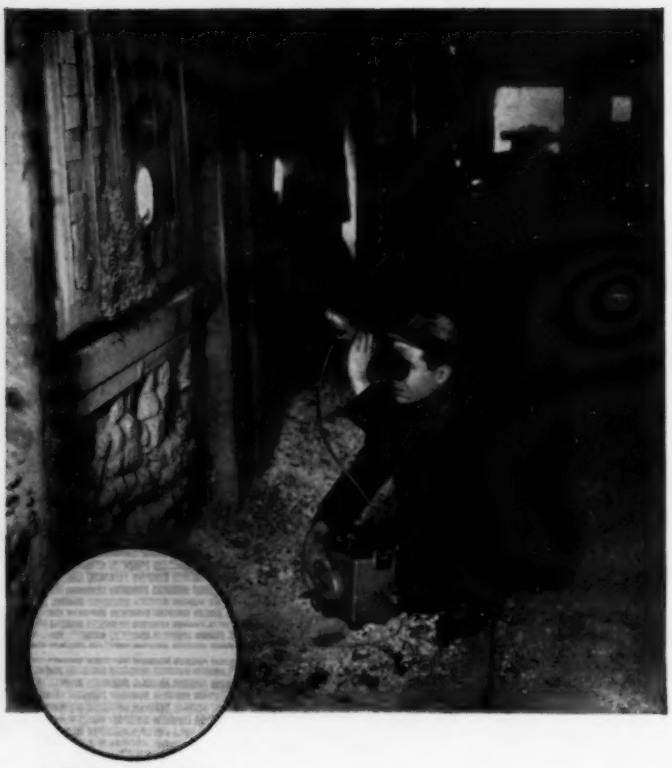
CONTINENTAL
Foundry & Machine
Company

With 2-Inch Tip

With 4-Inch Tip

TEEMING METAL AS SEEN WITH L&N OPTICAL PYROMETER

Note usefulness of Big Image when smaller does not approximately fill Pyrometer field.



With 2-Inch Tip

With 4-Inch Tip

FURNACE ROOF AS SEEN WITH L&N OPTICAL PYROMETER

Smaller Image is more useful, though either large or small can fill Pyrometer field.

Better INFORMATION ABOUT TEMPERATURE FROM *present* L&N OPTICAL PYROMETERS

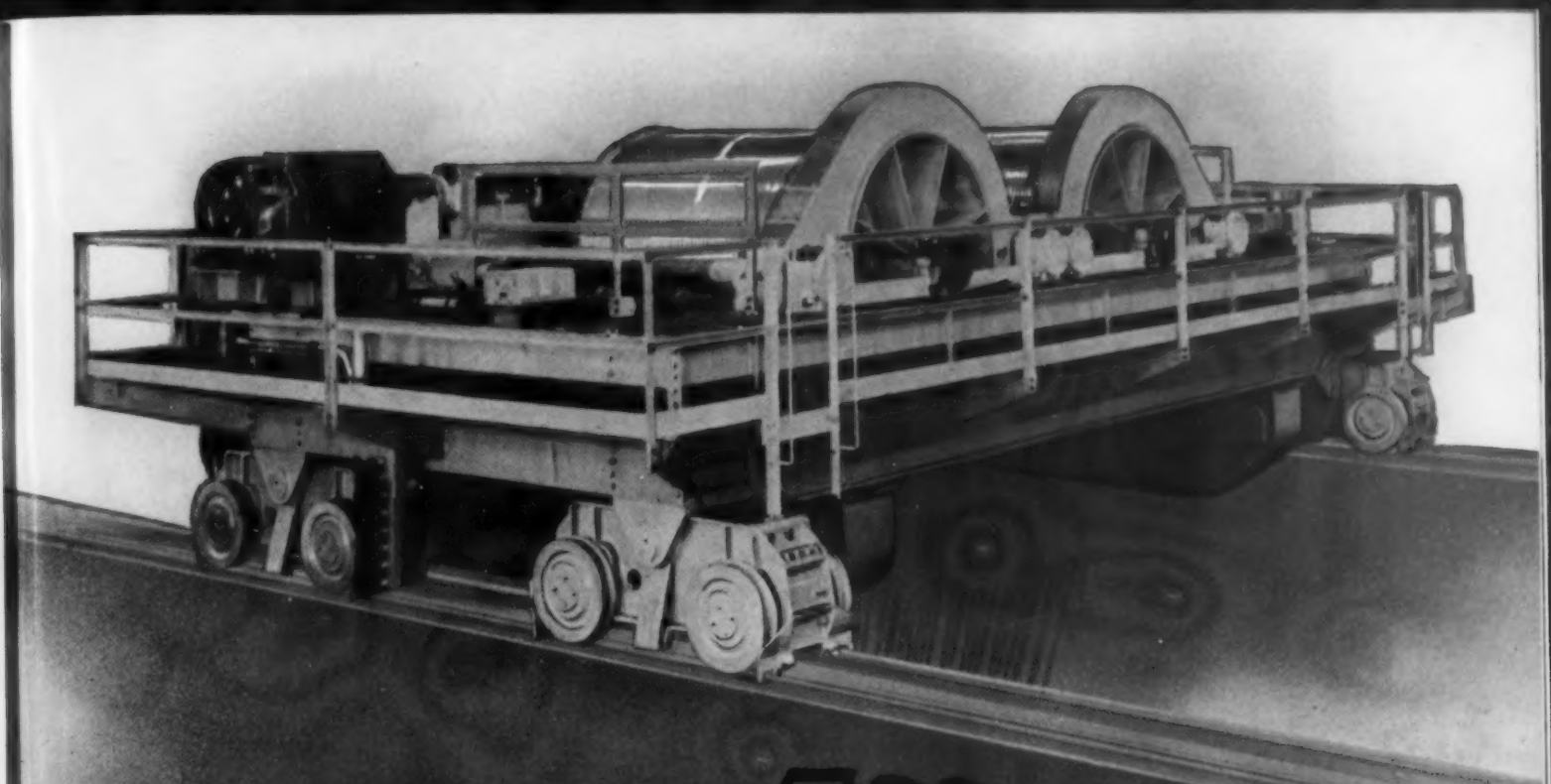
The important job of checking temperature by simply sighting an instrument on the hot object is the steel industry's task for L&N Optical Pyrometers. Because these Opticals hold their accuracy when ambient temperature rises or falls, they can be kept handy to the furnace, ready for use at any time. Because they use the potentiometer principle, these portable instruments measure dependably and accurately. And, now, they are easier to use than ever before because the user can have two choices in the apparent size of his "target." All that's needed is a pyrometer tip of 4″ focal length, to supplement the standard 2″ tip.

With the 2″ tip, the area seen by the user is 5½ inches in diameter at 5 feet; proportionately more or less at other distances. With the long tip, the field is the same size, but the image is twice as large, so that men who formerly had difficulty in getting readings now obtain them more quickly and with less effort.

Optical Pyrometers are available in Fahrenheit ranges from 1400 to 5200, or in the corresponding Centigrade ranges of 775 to 2800, or in convenient portions of each spread. Instruments can be direct-reading for the normal "black body" conditions inside a furnace, or for molten metals. All choices, as well as the extra tips, are fully described in Catalog N-33D, which also has many pictures showing equipments in use. For a copy, write Leeds & Northrup Co., 4942 Stenton Ave., Philadelphia 44, Pa.

LEEDS LN NORTHRUP
instruments automatic controls • furnaces

Jrl. Ad N-33D-0660(2)



TROLLEY FOR THE WORLD'S BIGGEST CRANE BY Alliance

Paul Bunyan used to brag about threading a needle with his enormous hands . . . but he has little on Alliance trolleys. Swiftly, but with the accuracy and control of a micrometer, the world's largest crane moves tons of molten steel with utmost safety.

The trolley is equipped with 16 double-flange track wheels which operate on rails at 30" centers. These wheels are compensated for longitudinal and transverse equalization which assures equal loading of all wheels. The rails being located over the web plates prevent flexing and cracking of top cover plate and reduces the number of diaphragms required.

This ladle crane trolley is equipped with a two-motor, synchronized worm drive, interlocked double-drum type main hoist. The synchronizing shaft employed in this scheme of gearing not only eliminates the undesirable ratchet gears but makes possible an additional safety feature in case one of the hoist motors fail. Under this condition both worms are driven by the remaining motor and all gearing functions as with two motors. In case of failure of one hoist motor on the conventional drive **without** the synchronizing shaft, hoisting is accomplished by **only one** set of gears. This imposes a double load on active gearing, the second drum being driven through the interlocking drum gears. The hoist gearing is so proportioned on all ladle cranes that the full capacity of the crane can be lifted by one motor without exceeding the quarter-hour rating.

The drum gears and pinions of the main hoist of this new crane have precision-cut, single-helical teeth, and in cooperation with the worm drive, assure vibrationless operation on either high or low speed hoisting and lowering.

All gears are fully enclosed and operate in a bath of oil, assuring long life and low maintenance.

This trolley is designed for maximum accessibility and ease of maintenance. Anti-friction bearings throughout.

The 4-part safety rope system installed on this crane affords the highest degree of safety in rope reeving.

Contact Alliance today. At your convenience a qualified engineer will discuss your heavy material handling problems. It's to your advantage.

LADLE CRANES • GANTRY CRANES • FORGING MANIPULATORS • SOAKING PIT CRANES • STRIPPER CRANES • SLAB AND BILLET CHARGING MACHINES • OPEN HEARTH CHARGING MACHINES • SPECIAL MILL MACHINERY • STRUCTURAL FABRICATION

THE

Alliance

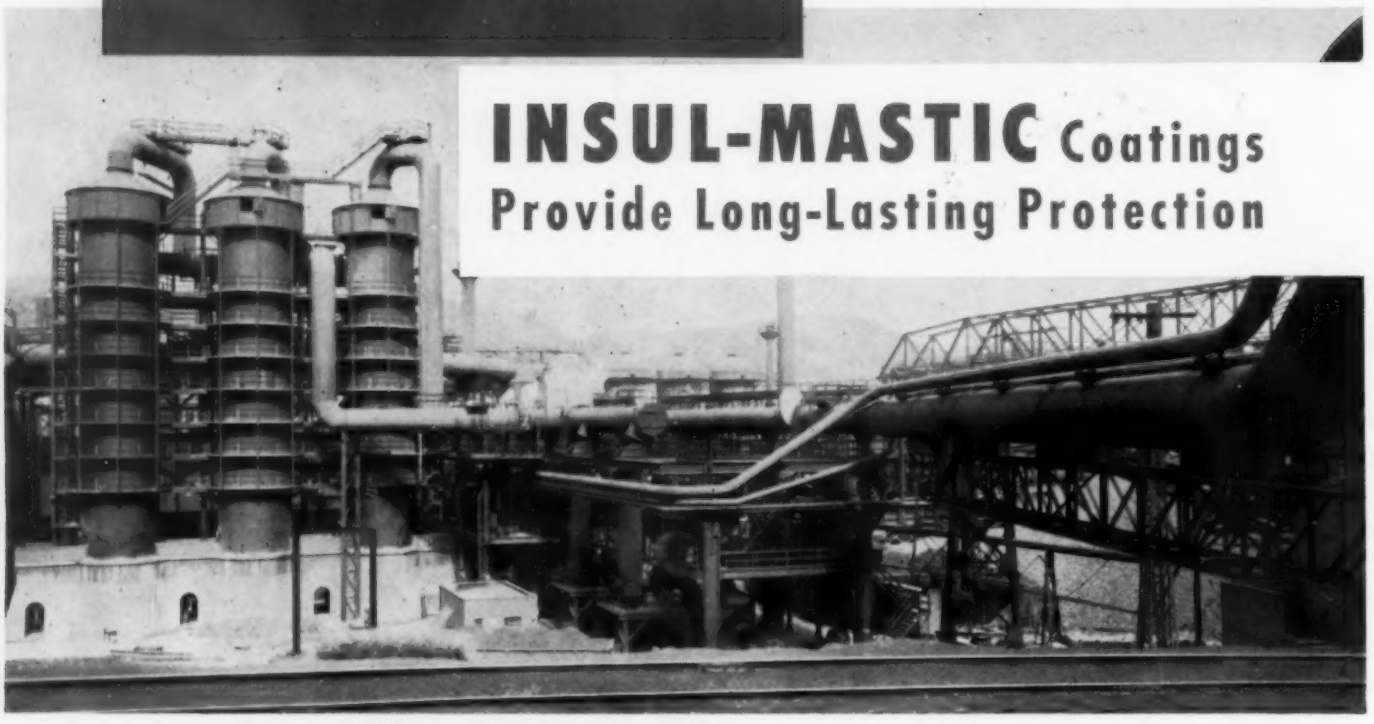
MACHINE COMPANY

World's largest builders of world's largest cranes

MAIN OFFICE
ALLIANCE, OHIO

PITTSBURGH OFFICE
1622 OLIVER BUILDING • PITTSBURGH, PA.

Everywhere you LOOK..



INSUL-MASTIC Coatings Provide Long-Lasting Protection

Practically everything in the blast furnace area seen above is coated with INSUL-MASTIC, to prevent corrosion.

This is the way that one large steel mill assures long life for its equipment. Some of the structures pictured have been coated for five years without maintenance, and there will be a great many more years of protection.

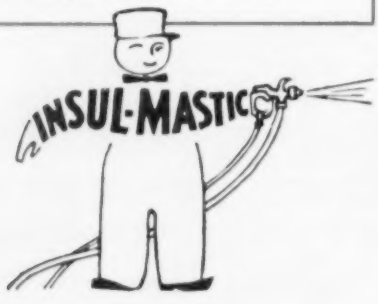
INSUL-MASTIC prevents corrosion in this and many other steel mills in spite of an almost constant rain of acid vapor from coke quenching operations. These coatings very capably resist corrosive chemicals and stop moisture penetration. That is the purpose for which they are made. They are also unharmed by sunlight and weather, a failing point of many coatings.

INSUL-MASTIC coatings resist abrasion yet are flexible enough to stand expansion and contraction of vessels without cracking. They have a temperature range of −40°F to +300°F.

Let these coatings reduce your maintenance operations and extend the life of your equipment. Write today for the address of your nearest INSUL-MASTIC representative.

Think first of the coatings that last!

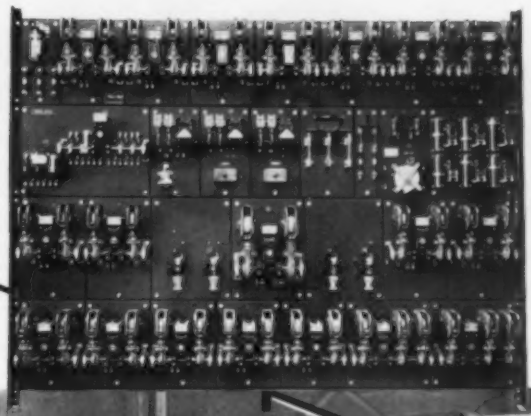
TAKE ADVANTAGE OF OUR CONSULTANT SERVICE. Don't risk needless future maintenance. Our engineers can tell you whether or not your construction or insulation needs a protective coating. There is no obligation. Write today!



Insul-Mastic

CORPORATION OF AMERICA
Oliver Building • Pittsburgh 22, Pa.
Representatives in Principal Cities

a job for EC&M Frequency Relay Control . . .



Installation in northern New Jersey of Nordberg balanced double cage slope hoist operated by two wound - rotor motors under EC&M Frequency Relay Magnetic Control.

Cage Creeps Up Or Down—Runs at Full Speed — Is Slowed Down From Operator's Master Switch.

PERFECT CONTROL

The passengers enjoy a velvet-smooth ride on this mine-hoist. EC&M Frequency Relay Control permits adjusting the torque of the two 200 hp, 440-volt wound rotor induction motors to cause the cage to creep, to run at full speed, or to operate at intermediate reduced speeds.

The operator's multi-speed-point EC&M Cam Master Switch makes speed selection quick and sure.

EC&M Frequency Relays automatically switch motor connections to maintain safe operation under all conditions.

Because of the highly efficient operation throughout the past five years of a similar hoist equipped with EC&M Frequency Relay Control, the user specified EC&M Control for this latest hoist installation. If you have a hoist problem, it will pay you to look into EC&M Control.

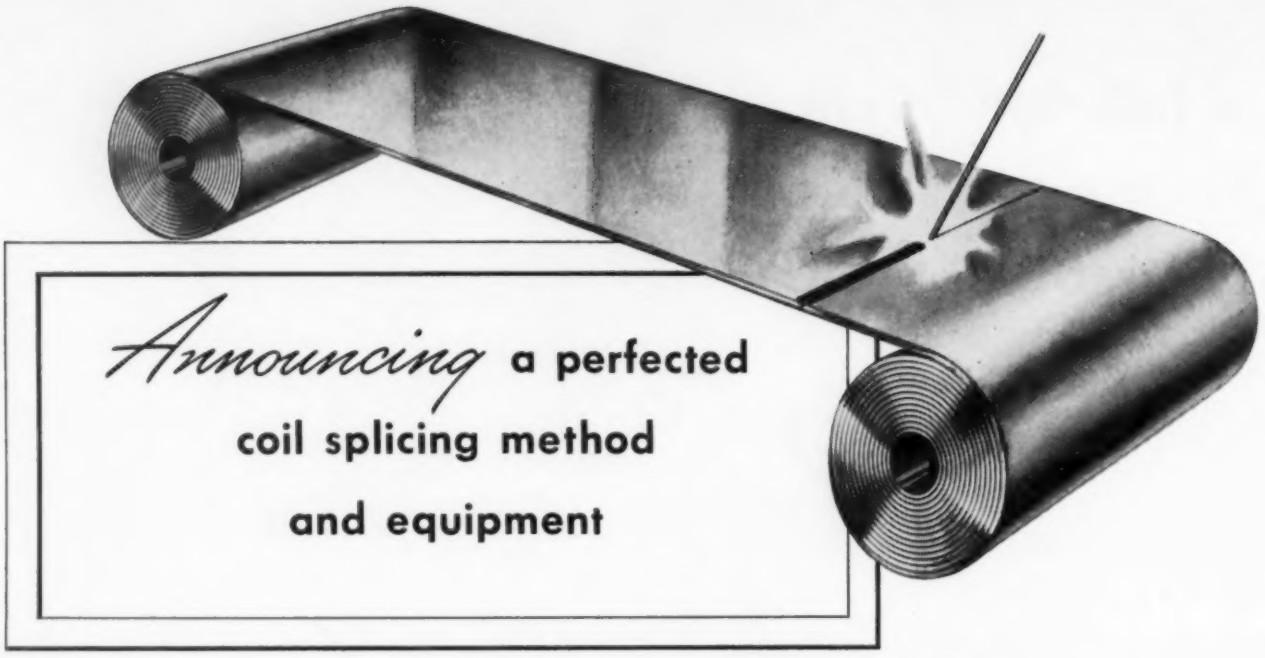
SMOOTH RIDE FOR MEN OR MATERIALS

1. Cage creeps to stop with passengers.
2. Cushioned acceleration during hoisting and lowering.
3. Slowdown by motors—EC&M Type WB Brakes set and hold the load.
4. Slow speed for rope inspection—about 12% of normal hoisting speed.

No. 28 ACCELERATOR Bulletin describes this EC&M hoist control system. Write for your copy.

THE ELECTRIC CONTROLLER & MFG. CO.

2698 EAST 79TH STREET ★ CLEVELAND 4, OHIO



Announcing a perfected
coil splicing method
and equipment

THE ARMS-FRANKLIN
Weld-a-matic COIL SPLICER*

*Pats. Applied For

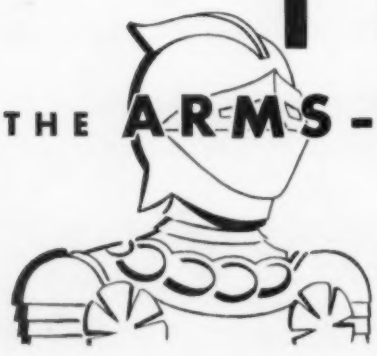
for carbon strip • silicon • stainless • aluminum • copper • brass

★
INCREASE PRODUCTION
★
REDUCE DOWN TIME
★
REDUCE SCRAP LOSSES

Today's answer to increased production, reduced mill down time and coil-end scrap is *larger coils* or an endless strip supply obtained by end-welding coils continuously.

The new Arms-Franklin *Weld-a-matic* Coil Splicer offers a perfected system for building-up coils to make high speed reducing operations more nearly continuous or production line end-welding to provide a constant strip supply.

The Arms-Frankin *Weld-a-matic* Coil Splicer is a completely integrated machine, combining all the necessary units, namely—guides, clamps, shear, and welder for preparing and making a weld in strip. It produces a streamlined, ductile splicing weld stronger than the parent metal on carbon steel, stainless, silicon steel, aluminum, copper and brass. Weld breakage is minimized and no trimming is required on the weld before entering mill rolls. The entire operation is controlled by push buttons—it is automatic, and requires no special training or welding skill.
Write today for facts.



THE ARMS-FRANKLIN CORPORATION
YOUNGSTOWN 1, OHIO

Producers of: Strip Coil Splicers, Coil Build Up Lines, Cleaning and Pickling Lines, Annealing and Inspection Lines, Slitting Lines, Grinding Lines, Cut to Length Lines, Payoff Reels, Tension Reels, Levellers, Shears, Classifiers and Other Auxiliary Equipment

WE PUT THE "CONTINUOUS" IN CONTINUOUS MILLS

ELIMINATE

~~Water Cooling~~

~~Wearing Skids~~

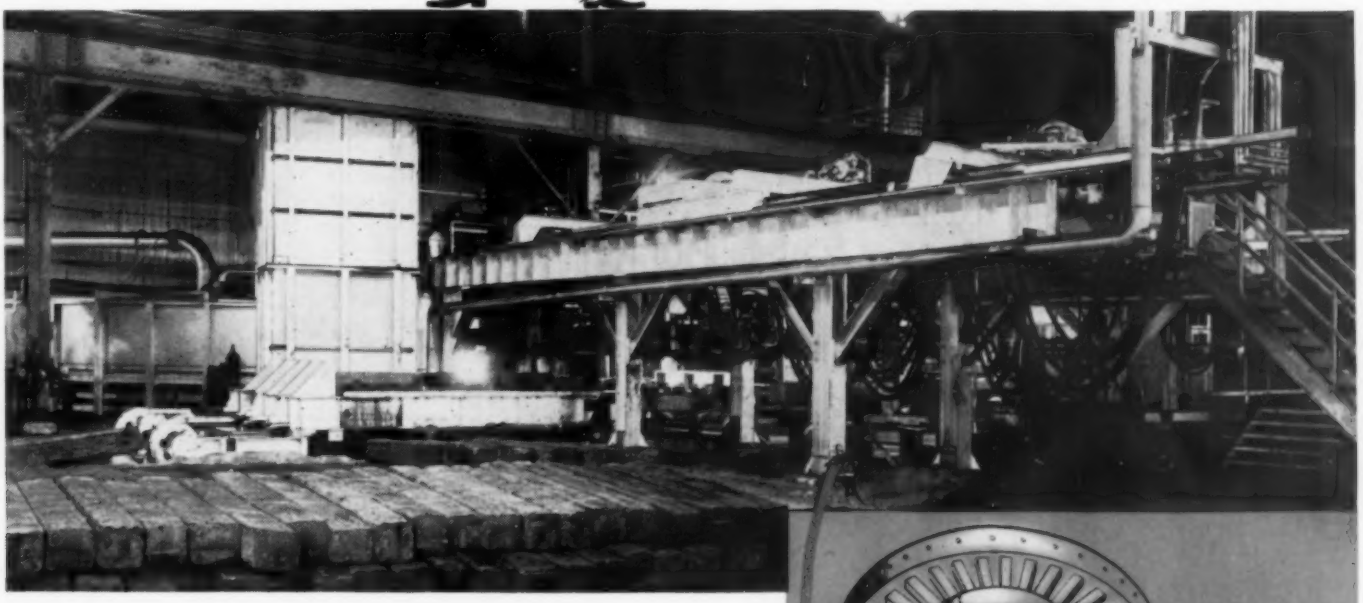
~~Stickers~~

~~Dummy Steel~~

HAGAN

Automatic Rotary

BLOOM HEATING FURNACE



Blooms charged and discharged *Automatically*

HAGAN AUTOMATIC ROTARY HEARTH FURNACES—

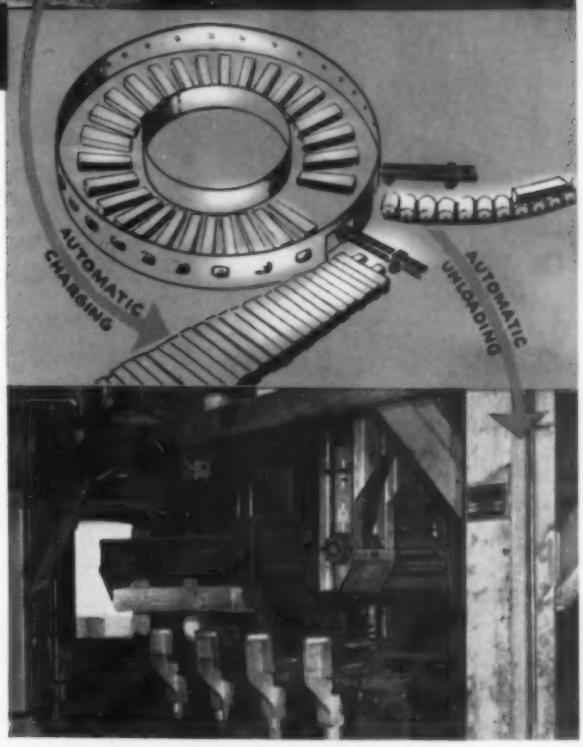
. . . **PERMIT** loading one, ten, twenty or more blooms into furnace to suit production requirements—under automatic control.

. . . **ELIMINATE** water cooled supports and skids. Blooms are automatically loaded and unloaded from a refractory hearth.

. . . **ELIMINATE** stickers. Blooms are handled individually and spaced apart on the hearth. Hearth can be unloaded at anytime without dummy steel.

. . . **PROMOTE** high efficiency by means of patented design, without recuperation by natural counterflow.

. . . **FURNISHED** from 9′ to 70′—and up to 100 tons per hour.

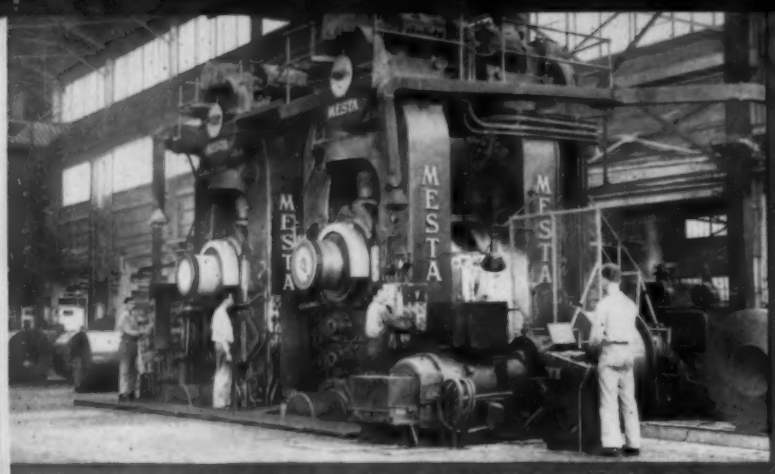


GEORGE J. HAGAN COMPANY

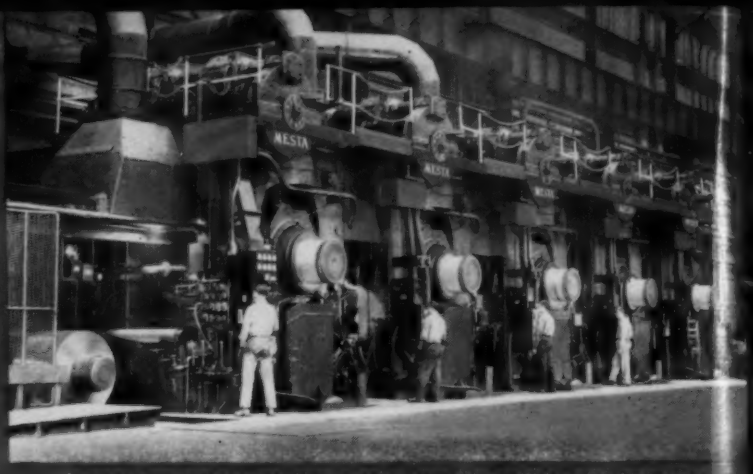
2402 E. Carson St., Pittsburgh 3, Pa.

CHICAGO • DETROIT

✔ *Check First with Hagan* **FOR ADVANCED ENGINEERING IN INDUSTRIAL FURNACE APPLICATIONS**



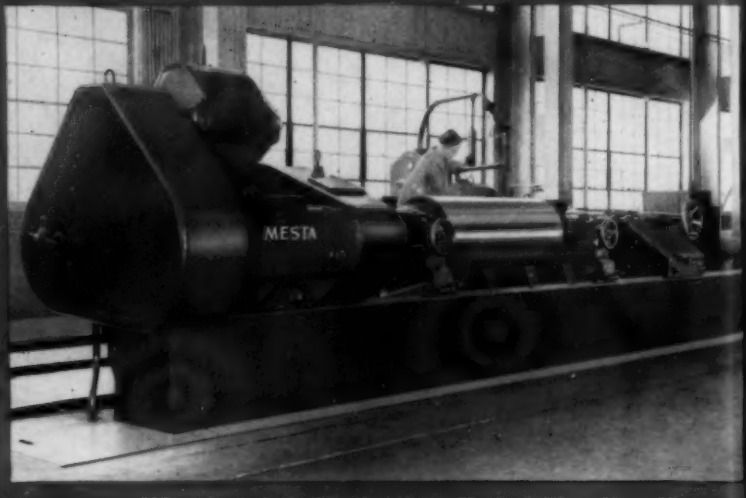
MESTA 42" FOUR-HIGH TWIN-STAND HIGH-SPEED SKIN PASS MILL



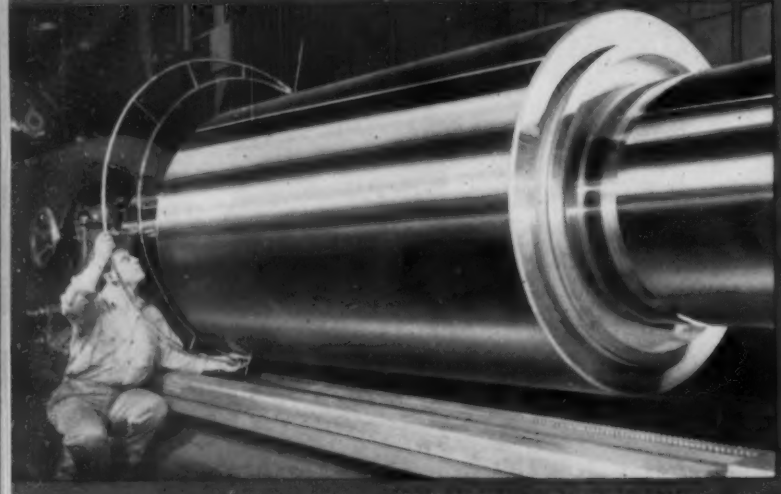
MESTA 56" FOUR-HIGH, FIVE-STAND HIGH-SPEED TANDEM COLD MILL

Designed and Built By

MACHINING A LARGE GEAR DRIVE BASE ON A MESTA HEAVY DUTY PLANER



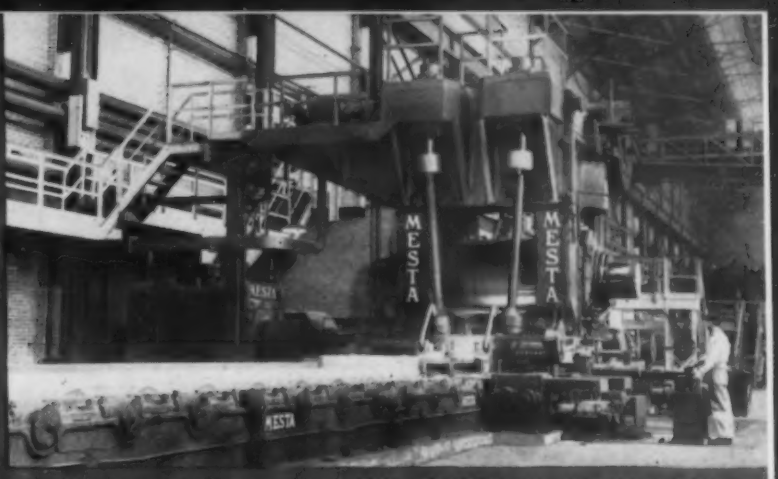
MESTA HEAVY DUTY TRAVELING WHEEL TYPE ROLL GRINDER



FINISH GRINDING A LARGE MESTA SPECIAL ALLOY CAST STEEL BACKING-UP ROLL IN A MESTA HEAVY DUTY ROLL GRINDER

FOUR MESTA HIGH-SPEED CONTINUOUS PICKLING LINES WITH TRIMMERS, UPCOILERS, AND MESTA-THOMSON FLASH WELDERS

MESTA 110" FOUR-HIGH REVERSING PLATE MILL



MESTA 68" FOUR-HIGH CONTINUOUS HOT STRIP MILL, UNIVERSAL STAND

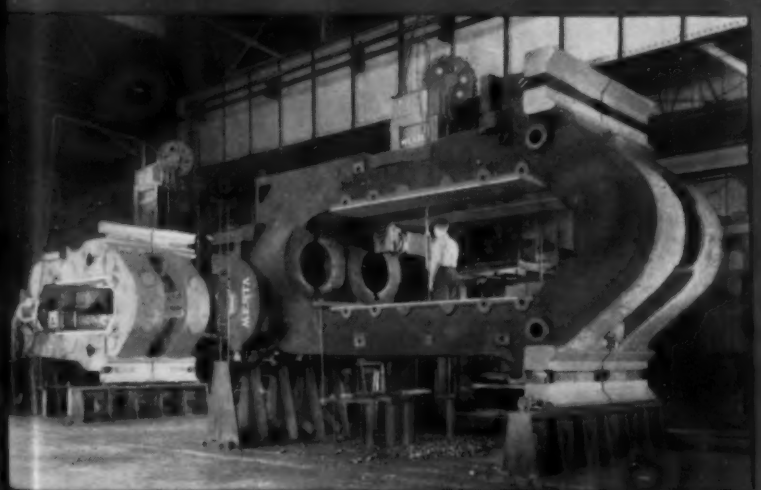
WORKING A HEAT OF HIGH QUALITY STEEL IN THE MESTA OPEN HEARTH DEPARTMENT

MESTA-THOMSON FLASH WELDERS LOCATED AT THE ENTRY END OF TWO MESTA CONTINUOUS PICKLING LINES

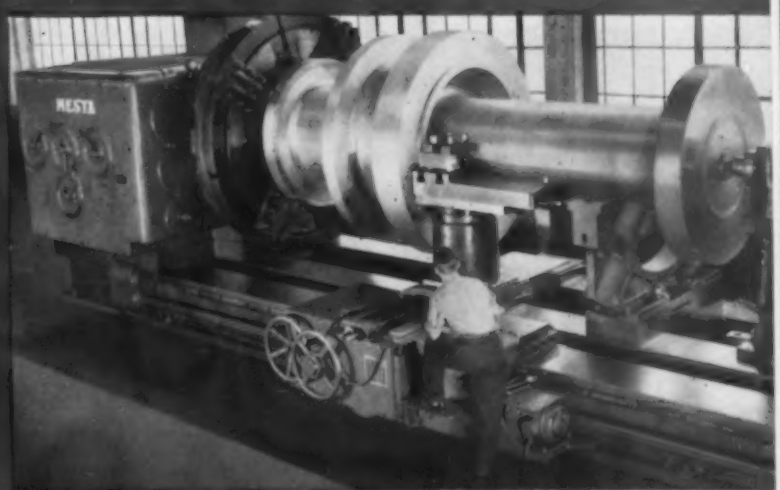
MESTA

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA



SIMULTANEOUSLY MACHINING ROLLING MILL HOUSINGS IN PAIRS ON MESTA HEAVY DUTY DRAW-CUT SHAPERS



TURNING A MASSIVE ROTOR SHAFT FORGED FROM INGOT POURED IN THE MESTA OPEN HEARTH DEPARTMENT

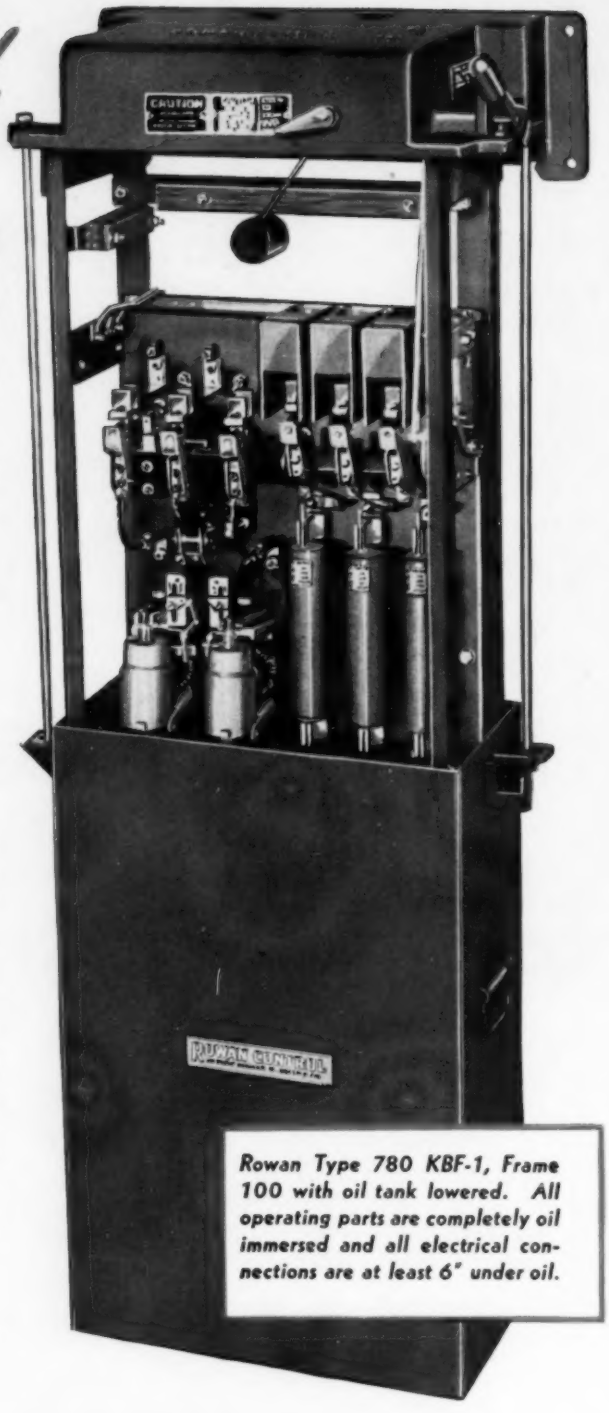
Oil Immersed

motor control for corrosive and hazardous locations

Designed for use in chemical plants, oil refineries, steel mills, cement plants, etc.—in locations where the atmosphere is corrosive or hazardous—Class 1, group D locations NEMA Type *VIII* enclosures.

Rowan Type 780 KBF-1 combination starters consist of heavy duty, magnetic contactors of the clapper type giving high-speed closing and opening with positive roll and wipe action; magnetic overload relays with inverse time element provided by means of Rowan AIR-SEAL dashpot—each relay individually tested and calibrated; safety disconnect switch of the contactor type with quick make and break mechanism—equipped with Rowan time-tested AIR-SEAL fuses. Top and tank are mechanically interlocked with the safety disconnect handle with provision for padlocking operating handle in the OFF position.

For complete information call the Rowan representative in your area.



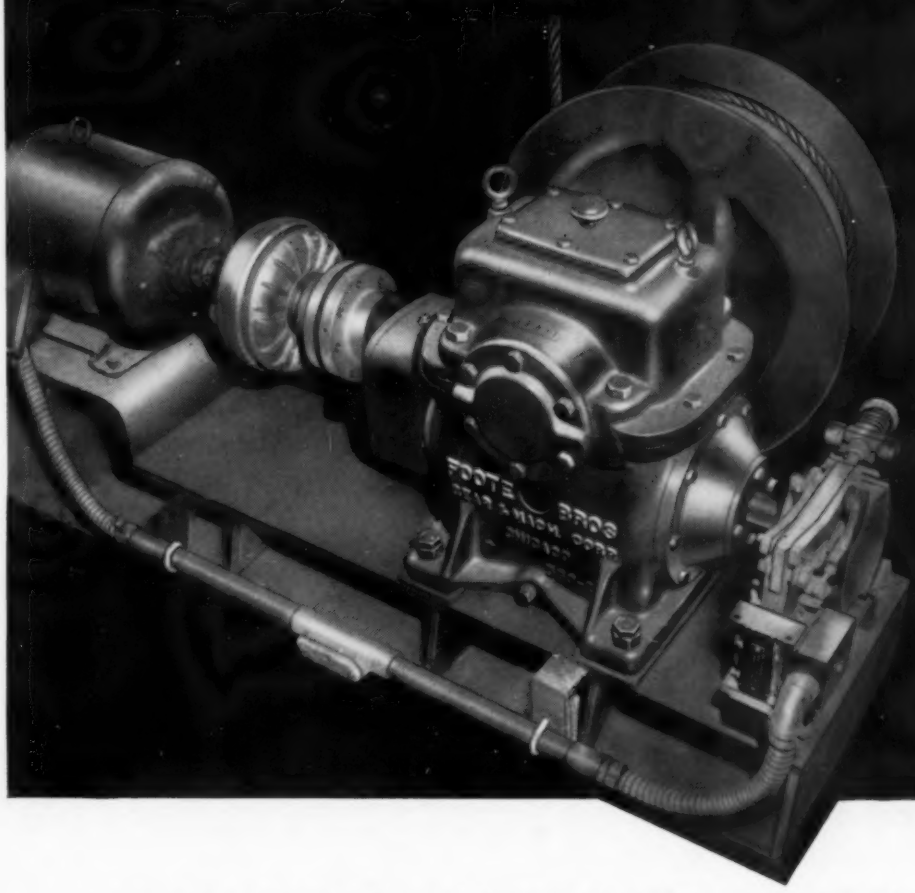
Rowan Type 780 KBF-1, Frame 100 with oil tank lowered. All operating parts are completely oil immersed and all electrical connections are at least 6" under oil.

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.

TOUGH JOBS MADE EASY...

WITH FOOTE BROS. HYGRADE DRIVES... MORE STAMINA IN LESS SPACE



Horizontal Hygrade Drive operating door-control cable of open hearth furnace at Fairless Works, United States Steel Corporation. For purposes of illustration, safety guard over coupling has been removed.

Steel making is a rugged, 'round-the-clock job. And Foote Bros. Hygrade Drives have the stamina for such typical, tough service — like this Hygrade at U. S. Steel's Fairless Works.

Sturdy, compact Hygrade Drives are built especially for heavy-duty applications — ratios range up to 4,108 to 1, capacities up to 260 h.p. But Enclosed Hygrade Drives are also designed to meet area limitations — modern, space-saving housings have been engineered around new-process, high-efficiency worm gearing to assure maximum performance in minimum space.

For optimum load-carrying capacity — for maintenance-free operation — for day-after-day service under the most rugged conditions... select Foote Bros. Hygrade Worm Gear Drives. There's a complete line — a size and type to meet all your requirements. Available with either horizontal or vertical output shaft. For special applications, Vertical Hytop Hygrade provides a long, extended, output shaft without additional support. For prompt delivery, call your Foote Bros. representative or write for bulletin.

Line-O-Power Drives

Foote Bros.-Louis Allis Gearmotors

Maxi-Power Drives

This Trademark Stands for the Finest in Industrial Gearing

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 South Western Boulevard • Chicago 9, Illinois

Foote Bros. Gear and Machine Corporation
Dept. IAS, 4545 South Western Blvd., Chicago 9, Illinois

Please send Bulletin HGB. I understand it contains full information on Hygrade Drives.

Name.....

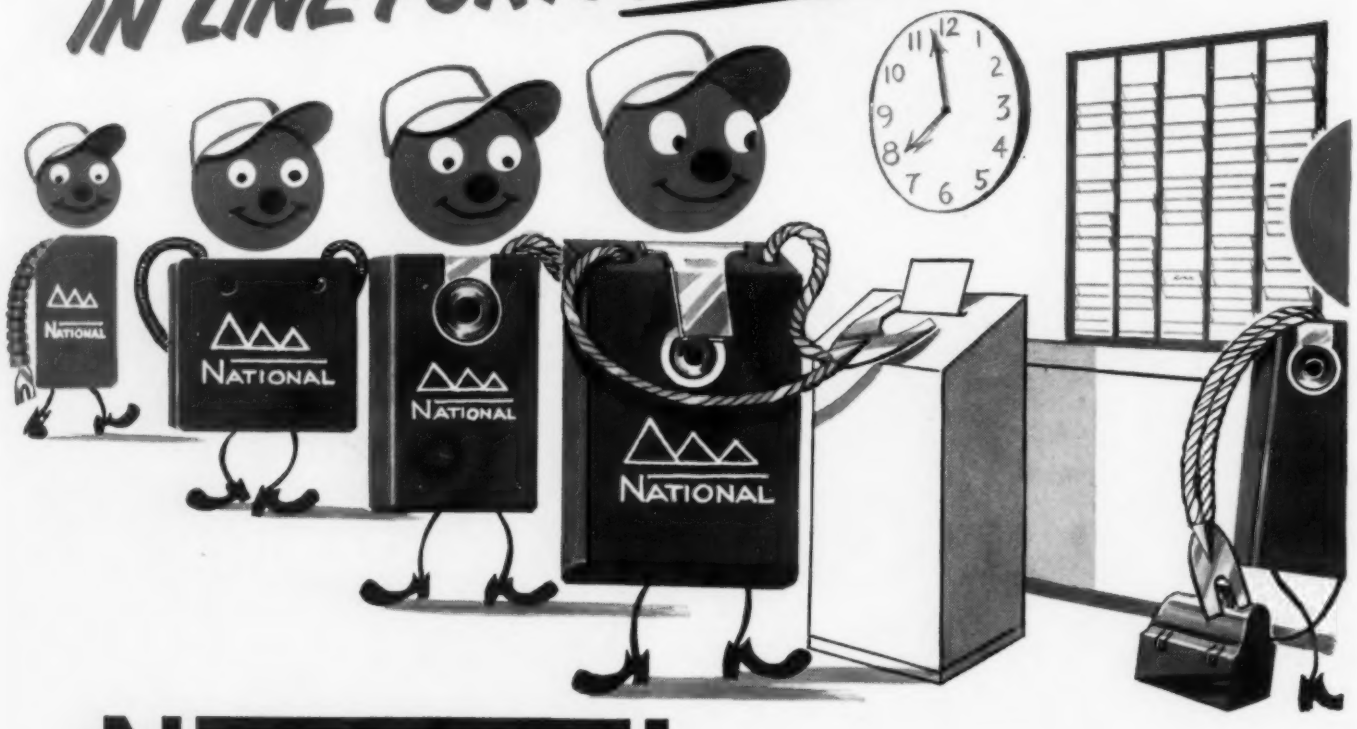
Position.....

Company.....

Address.....

City..... Zone..... State.....

IN LINE FOR A BETTER JOB...



NATIONAL BRUSHES FOR
TRADE-MARK

MAIN-DRIVE, MILL-TYPE and GENERAL-PURPOSE MOTORS

Here's what the "National" brush line will do for the operating departments of your company:

ELECTRICAL: National Carbon's concentration on uniform brush grades of wide-range applicability simplifies brush selection . . . helps you set up your own standardization program using fewer types and sizes.

MAINTENANCE: The low friction, superior commutating ability and long life of "National" brushes reduce commutator maintenance . . . cut costs and keep production at high sustained levels.

PURCHASING: Large numbers of stock and catalog items speed delivery of "National" brushes. And, remember, when you order "National" *Standardized* brushes, you really hit the jack-pot — low, flat prices regardless of quantity plus immediate shipment from stock.

STORES: National Carbon's improved packaging pays off in quick identification, ease of handling and stacking, fewer and sturdier cartons.

HOW GOOD IS REALLY GOOD BRUSH PERFORMANCE?
Write National Carbon Company

The term "National", the Three Pyramids device, and the Silver Colored Cable Strand are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

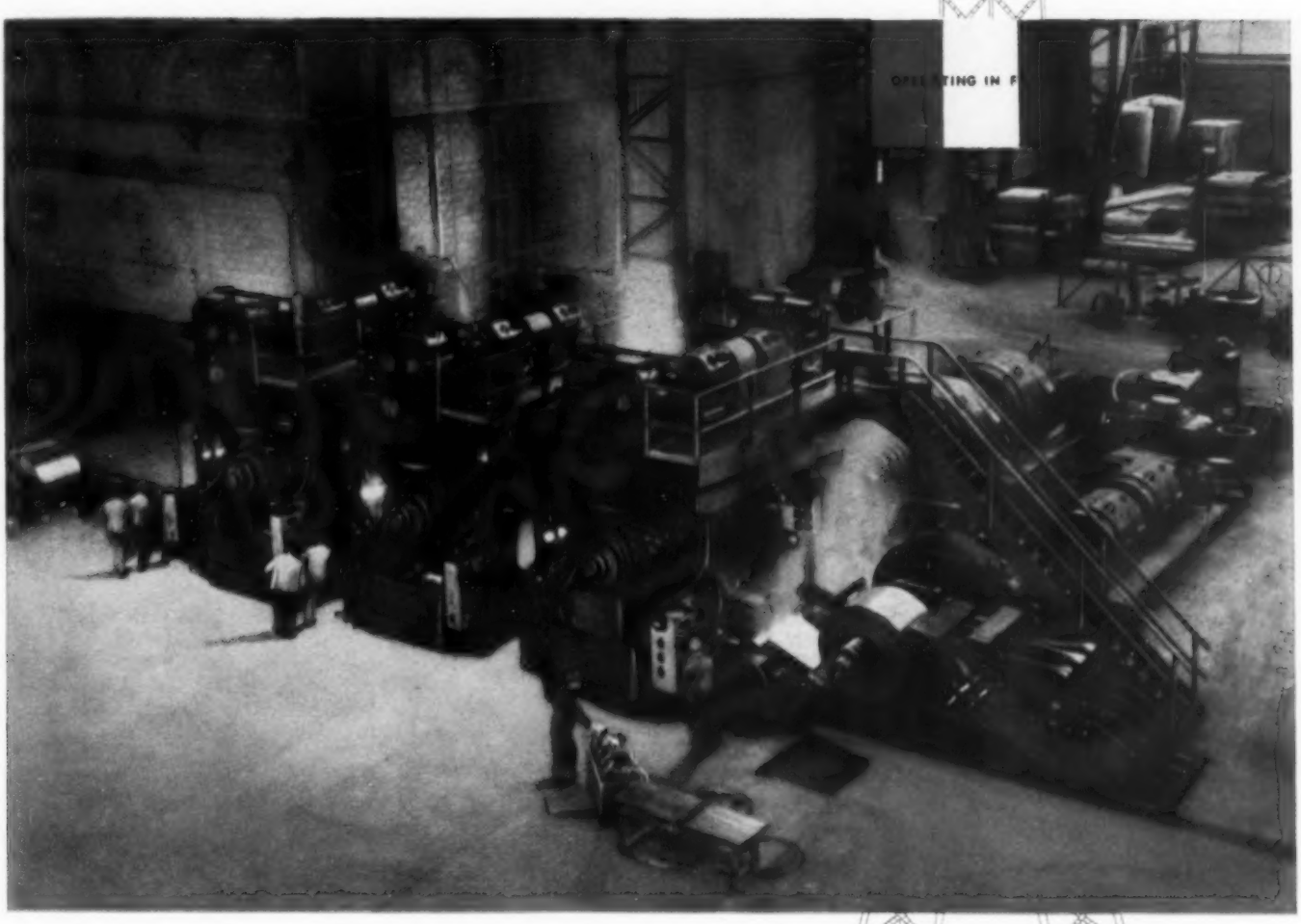
In Canada: NATIONAL CARBON LIMITED
Montreal, Toronto, Winnipeg

NATIONAL STANDARDIZED BRUSHES
BETTER— PRODUCT—PACKAGE—PRICE— FASTER

UNITED

®

4-HIGH 3-STAND TANDEM COLD MILL



UNITED

ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

Plants at: PITTSBURGH • VANDERGRIFT • NEW CASTLE • YOUNGSTOWN • CANTON

Subsidiaries: ADAMSON UNITED COMPANY, AKRON, OHIO
LOBDELL UNITED COMPANY, WILMINGTON, DELAWARE
STEDMAN FOUNDRY AND MACHINE CO., INC., AURORA, INDIANA

UNITED CAN SERVE YOU . . .
NO MATTER WHERE IN THE WORLD YOU ARE

Designers and Builders of Ferrous and Nonferrous Rolling Mills, Mill Rolls, Auxiliary Mill and Processing Equipment, Presses and other Heavy Machinery
Manufacturers of Iron, Nodular Iron and Steel Castings, and Weldments

ASKANIA

AUTOMATIC REVERSAL SYSTEM FOR REGENERATIVE FURNACES

The Askania Reversal Cabinet is the modern tool for reversing firing direction in a regenerative furnace. It insures accurate timing, unvarying correct reversal sequence, and absolute safety. Reversal is automatic, from time or checker temperature, or semi-automatic by pushbutton, if desired.

Askania automatic reversal eliminates error, and saves money too. It increases furnace capacity by minimizing fuel-off time. It prolongs checker life. It saves fuel by using checker heat to best advantage.

Check these Askania features—

1. Engineered by control engineers.
2. Complete safety interlocks.
3. The firing sequence never varies.
4. Increases furnace capacity.
5. Greater fuel economy.
6. Increases checker life.
7. Compact—all controls in one place.
8. Frees operator for other duties.
9. Operator is in full command at all times.
10. Easy to install and maintain.
11. Works with simple, inexpensive valves.

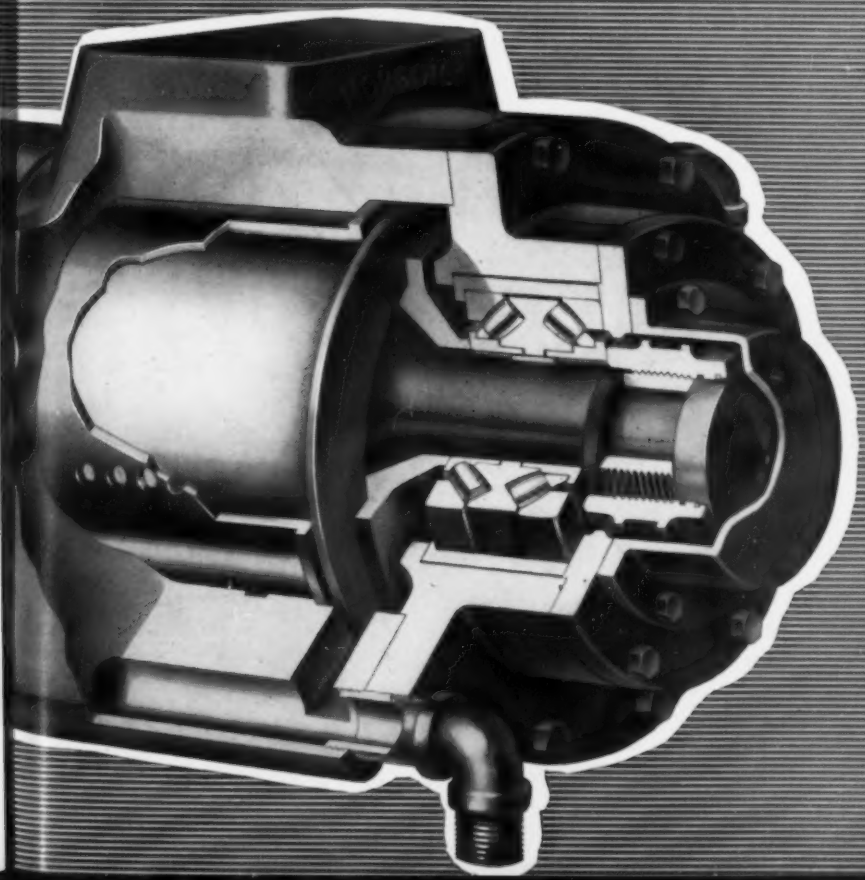
Write for Bulletin 159.

ASKANIA REGULATOR COMPANY
246 E. Ontario Street, Chicago, Illinois
Subsidiary of General Precision Equipment Corp.

MORGOIL
ROLL NECK BEARINGS

Aluminum Alloy bushings have been tested in MORGOIL Bearings on all types of 2-high and 4-high mills, in the plants of many of our customers and have definitely proven their superiority under the most grueling of operating conditions . . . . .

They are now supplied as standard equipment.

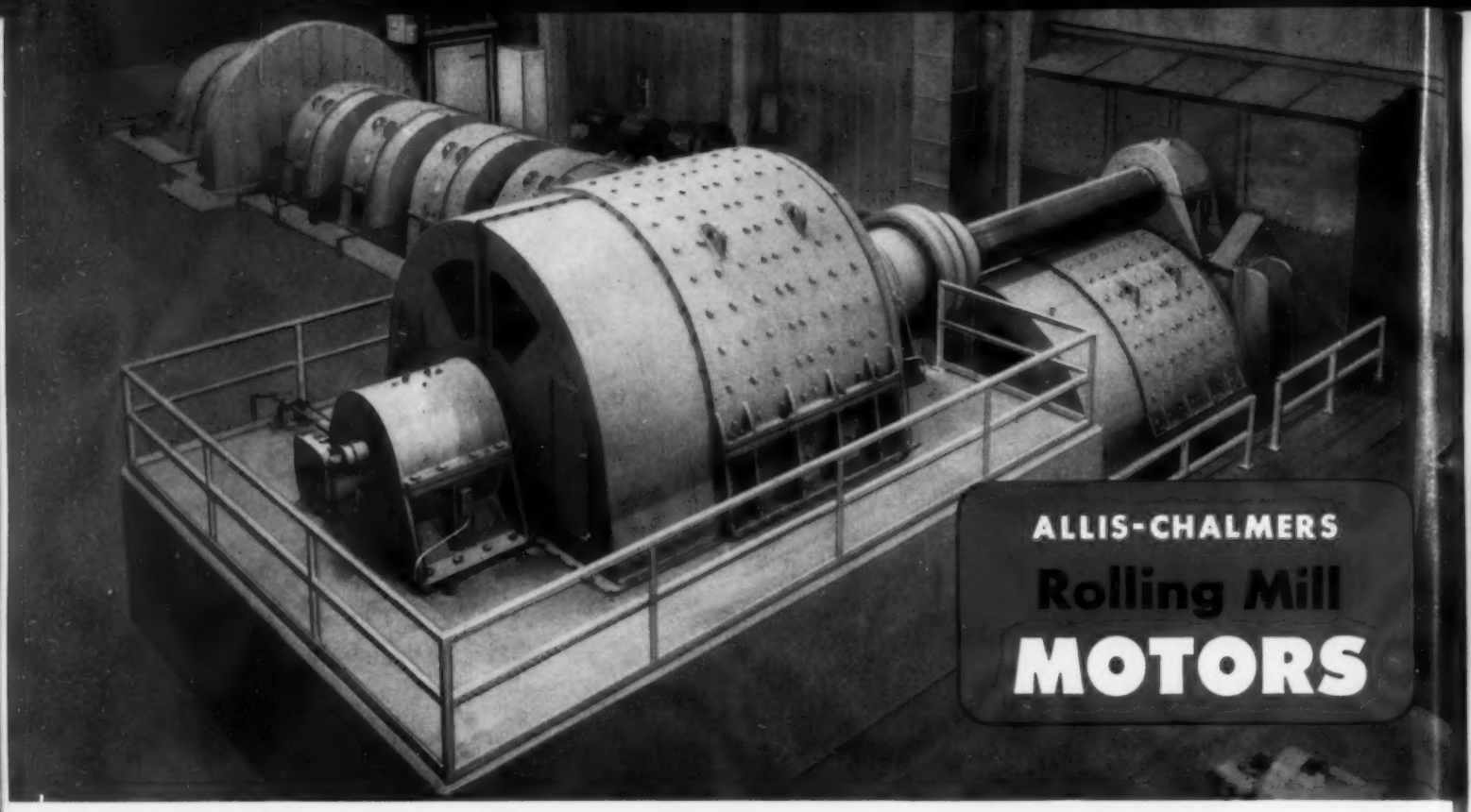


MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

ROLLING MILLS - MORGOIL BEARINGS
WIRE MILLS - GAS PRODUCERS - AIR EJECTORS
REGENERATIVE FURNACE CONTROL

English Representative International Construction Company, Ltd.
56 Kingsway, London, W.C. 2, England

MB-21



Shakedown Time ZERO!

Installation completed April 1. Production started April 2—at 200 tons an hour.

That's the story of the missing shakedown run at Granite City Steel Company's new 45 by 115-inch, two-high reversing blooming mill. (Eight days later the old blooming mill was torn out, since it was obvious that temporary standby equipment was not needed.)

All electrical equipment for this mill was supplied by Allis-Chalmers. Pictured above is the 10,000-hp, 40/80-rpm twin drive and supporting flywheel and excitation m-g sets. A-C is also furnishing the electrical equipment for a new roughing mill and for revamping a finishing mill.

Completion of their current $50,000,000 expansion program later this year will give Granite City Steel a capacity well over a million ingot tons a year.

To see how much A-C's wide experience with metal rolling applications can benefit you, call your nearest A-C steel mill representative, or write to Allis-Chalmers, Milwaukee 1, Wisconsin. A-4100

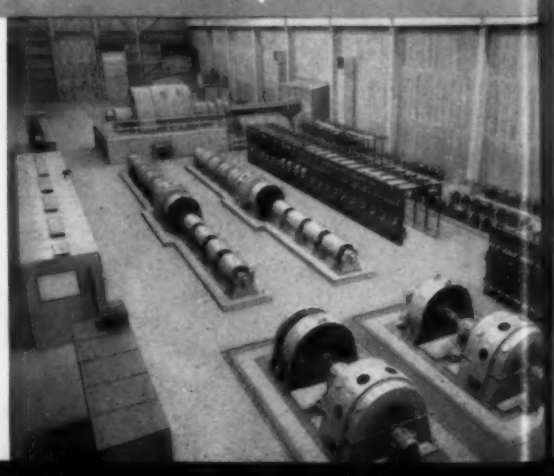
This ad appears in: Blast Furnace and Steel Plant...Iron Age...Iron and Steel Engineer...Steel

ALLIS-CHALMERS

At left, Granite City Steel's new blooming mill viewed from the main pulpit.

Over-all view of motor room (right) shows ac control and switchgear at left; constant and variable voltage m-g sets in center; dc control panels and *Regulex* exciter sets at right; and the two 5000-hp twin-drive motors and m-g sets in background—all supplied by Allis-Chalmers.

Regulex is an Allis-Chalmers trademark.



BIRDSBORO

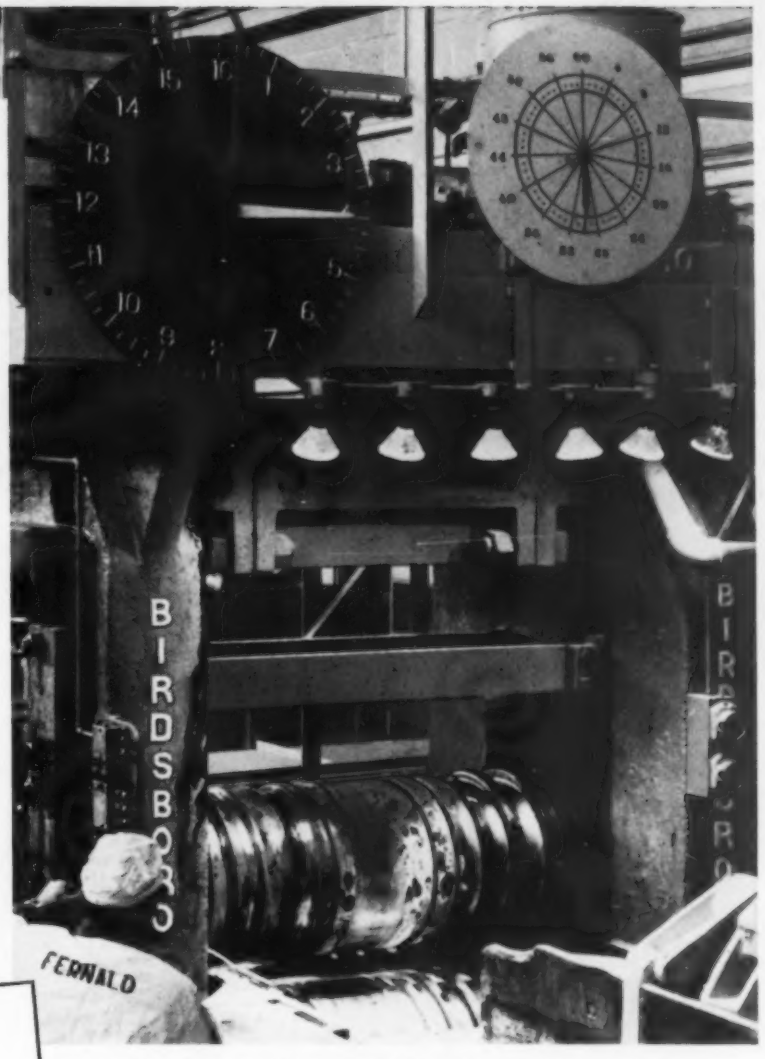
Builds the First and Only

URANIUM ROLLING MILL

and the A.E.C. says:

"... an outstanding performance in designing and manufacturing a special mill to roll uranium for the United States Atomic Energy Commission."

"... an extraordinary achievement in terms of speed ... a credit to your Company, and to the high ability of your staff."



UNITED STATES
ATOMIC ENERGY COMMISSION
NEW YORK OPERATIONS OFFICE

April 3, 1953

Mr. J. M. McCauley, President
Birdsboro Steel Foundry & Machine Company
Birdsboro, Pennsylvania

Dear Mr. McCauley:

It is with pleasure that I commend Birdsboro Steel Foundry & Machine Company, and in particular the Engineering Department of its Rolling Mill Division, on an outstanding performance in designing and manufacturing a special mill to roll uranium for the United States Atomic Energy Commission. Not only was this an extraordinary achievement in terms of speed, but the costs of the mill have been held well in line with the original estimates which were projected from quite sketchy information. This is indeed a credit to your Company, and bespeaks the high ability of your staff. . .

Again I wish to thank and commend you, and through you the Birdsboro staff, on an excellent job.

Very truly yours,

H. B. Fry
Manager

M:HBF:ab

•This primary Birdsboro mill, followed by a continuous Birdsboro finishing mill, built under contract for Catalytic Construction Co., is used to roll uranium into bars for further fabrication into slugs used in nuclear reactors.

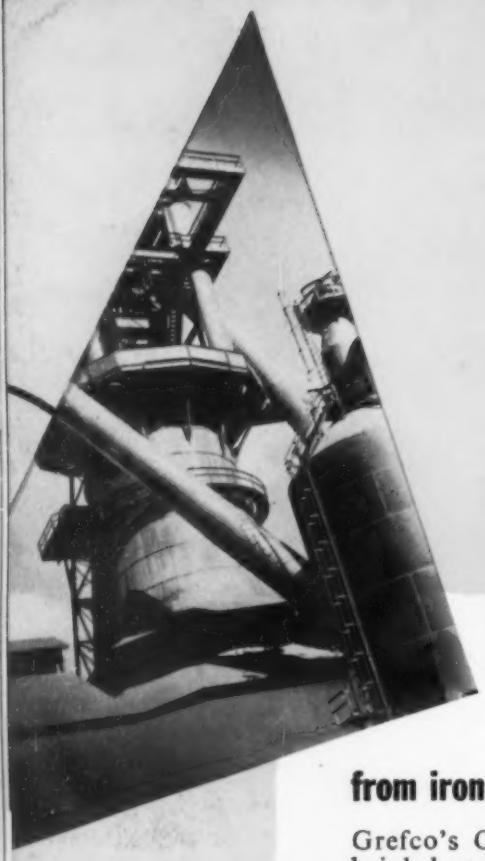
BIRDSBORO brought more than 58 years of experience and engineering skill to bear on the task of producing the new uranium rolling mill for the A.E.C.'s uranium production center at Fernald, Ohio. Today, the mill—first and only one designed for production rolling of uranium—is in steady, high volume production.

Now, as in the past, BIRDSBORO offers you this same experience and know-how in your search for better, lower-cost mill rolling operations. Make it a point to call in BIRDSBORO engineers.

BIRDSBORO

BIRDSBORO STEEL FOUNDRY & MACHINE CO., BIRDSBORO, PENNA. STEEL MILL MACHINERY Offices in Birdsboro, Pa. and Pittsburgh, Pa.

•***designers and builders of:*** Steel Mill Machinery • Hydraulic Presses • Crushing Machinery • Rolls • Special Machinery • Steel Castings



from iron...

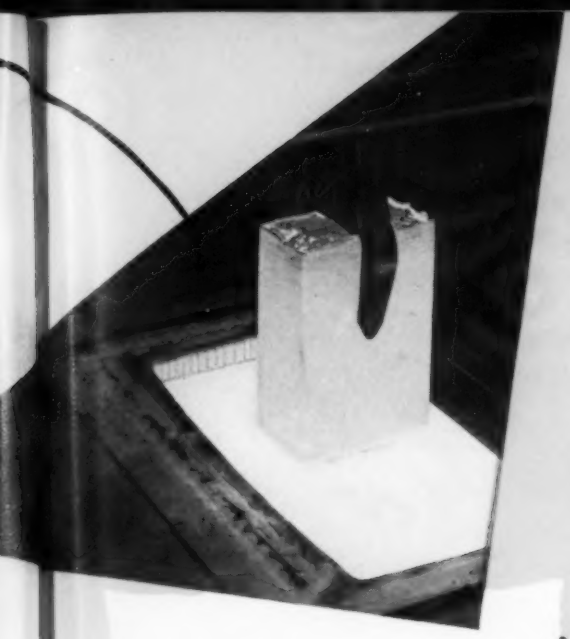
Grefco's OLIVE HILL brick has proved its ability to pour out production through longer campaigns . . . has long been a favorite with steel men in blast furnace application.

to steel...

In the open hearth, Grefco's silica, RITEX chrome-magnesite basic brick... and STEELKLAD, Grefco's patented basic brick encased in a permanent steel shell have contributed *much* to modern steel production.

it's

GENERAL REFRACTORIES



to supply!

Even the railroad cars in which the plate, sheet, strip or wire are shipped would not exist but for Grefco's truly *complete refractories service.* Call on Grefco yourself!

and ingot...

YOUGH silica brick, STEELKLAD and RITEX are superior refractories for lining soaking pits. From coast to coast and border to border, wherever there is a steel mill and soaking pit, chances are you'll find Grefco dependably on the job

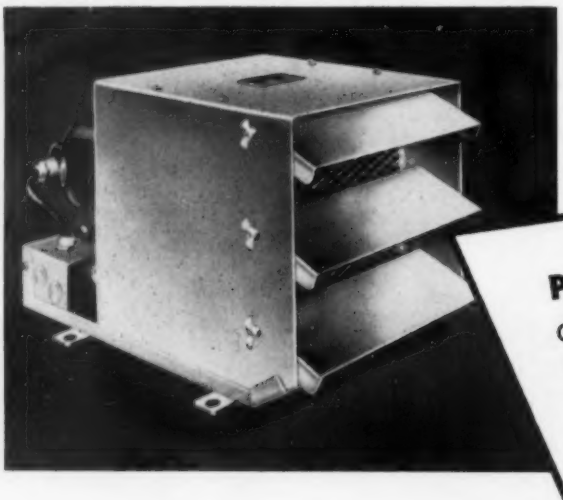
Grefco all the way!

GENERAL REFRACTORIES COMPANY

PHILADELPHIA

instant heat where you want it... WITH THESE TWO

P-G CONVECTION HEATERS



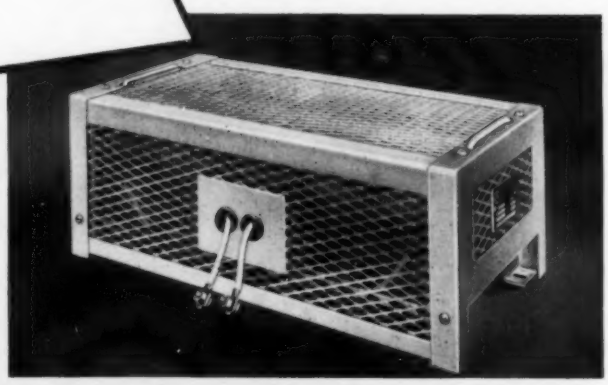
P-G Forced Convection Heater

Capable of moving a large volume of air with little noise. A 250 Volt D. C. Compound Wound Ball Bearing Motor of ¼ H. P. drives the fan. The heating circuit is controlled by a separately mounted 50-Ampere Magnetic Contactor energized thru a snap switch. The fan circuit is controlled thru a snap switch and contains a rheostat to vary the fan speed. Heating elements from 4 to 9 KW capacity, 230-250 Volts, D. C., are available.

P-G Natural Convection Heater

Ruggedly constructed, yet light in weight, they are easily portable by repair or construction workers. Ideal for permanent wall or floor mounting in crane cabs, etc. If a portable unit is desired, its disappearing handles may be used for ease in carrying. Made regularly in 3 to 6 KW capacity, 250 Volts, D. C.

TWO TYPES of HEATERS are available for industrial service. The heating element of both units is made of P-G Type T2, Chromium Steel Grids, which, because of their thin cross section, develop an unusually large heating area. A greater volume of warm air is so produced, and in addition, a more uniform heat distribution is obtained.



P-G

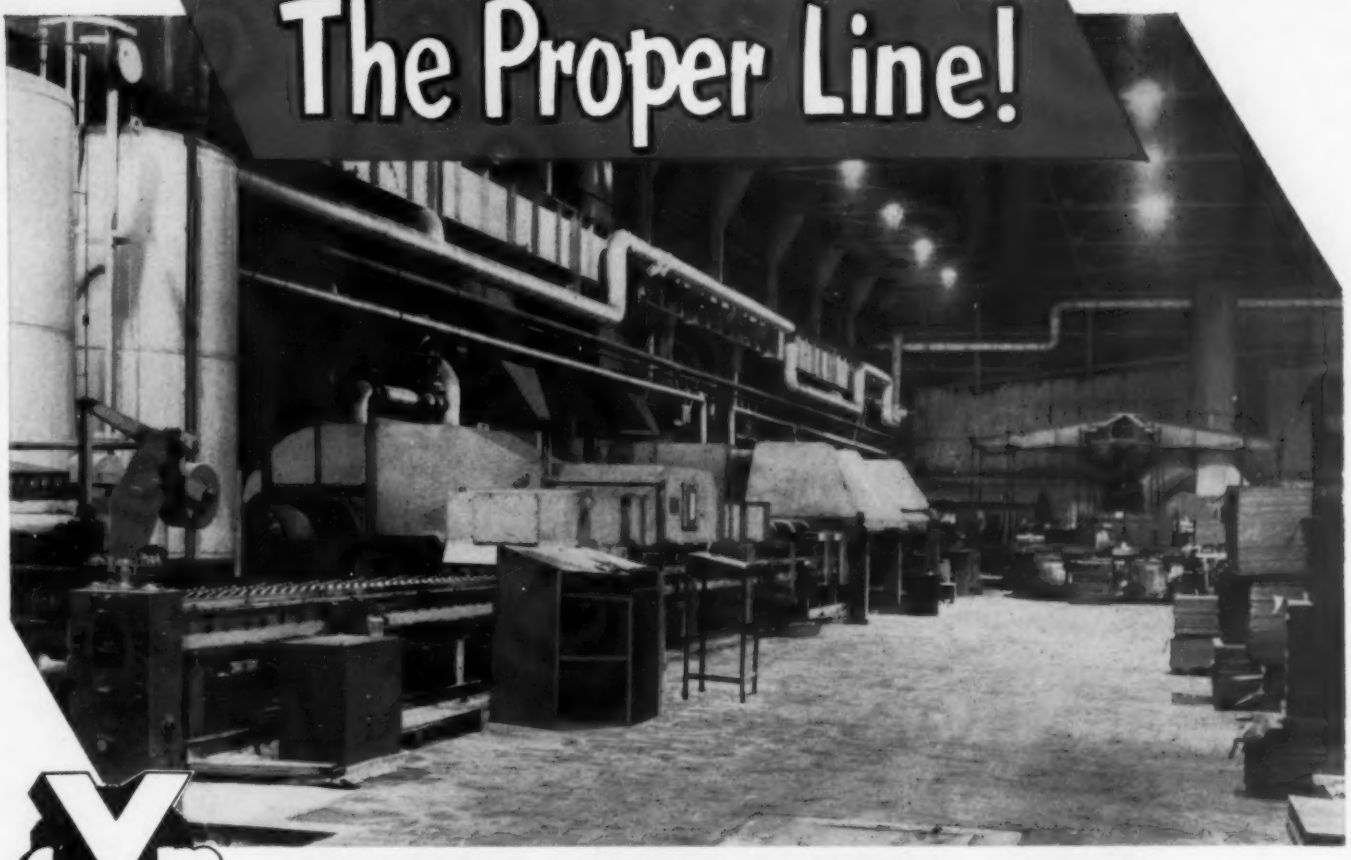
Write for BULLETIN NO. 600

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

221 WEST THIRD STREET, CINCINNATI 2, OHIO

The Proper Line!



F&Y

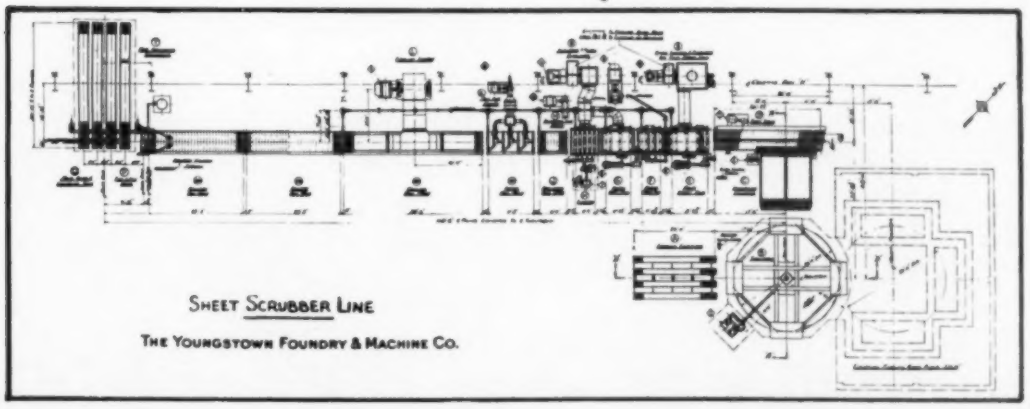
SHEET SCRUBBER LINE

• • • built for The Youngstown Sheet & Tube Company's Indiana Harbor Plant

The answer to your

- ENAMEL SHEET STOCK
- SHEETS FOR TIN PLATING
- SPECIAL SURFACE SHEETS
- DRY OR OILED STOCK

problems!



SHEET SCRUBBER LINE

THE YOUNGSTOWN FOUNDRY & MACHINE CO.

The Youngstown Foundry & Machine Co.

OVER SIXTY YEARS OF SERVICE TO THE STEEL INDUSTRY

Youngstown, Ohio

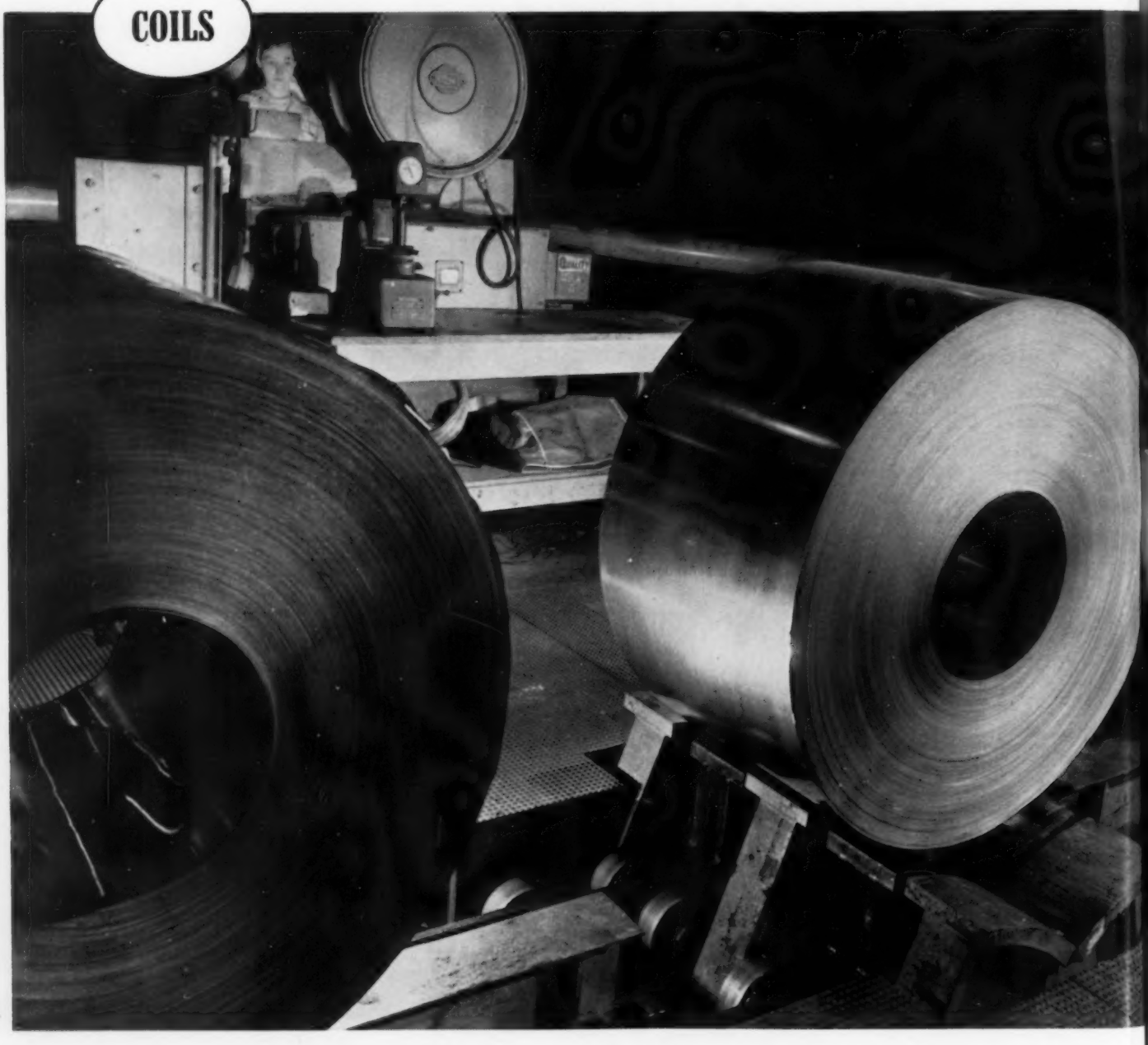
11

YIELD GOES UP

...when you mechanize your mill with LINK-BELT conveyors...every step of the way

IN MILLS all over the country, Link-Belt conveying systems cut the costs of steel making. Handling steel in every form, this fast, safe, economical transportation reduces scrap losses, increases yield. Take coils, for example. Up to 75,000-lb. coils are presently handled gently from coilers to storage or shipment, with no telescoping or edge damage. Get in touch with the Link-Belt office near you. Our engineers will work with your own engineers, consultants and builders of mill and process equipment—give you the right conveying system for your needs.

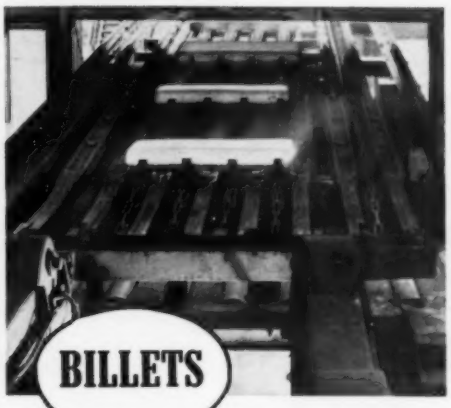
COILS



...WASTE DOWN

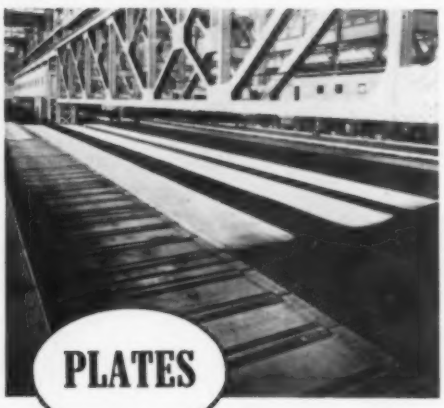
SLABS

Up to 70 tons of hot steel slabs are carried easily from shear to billet yard with this Link-Belt 4-strand chain conveyor. At right: Link-Belt apron conveyor for crop ends.



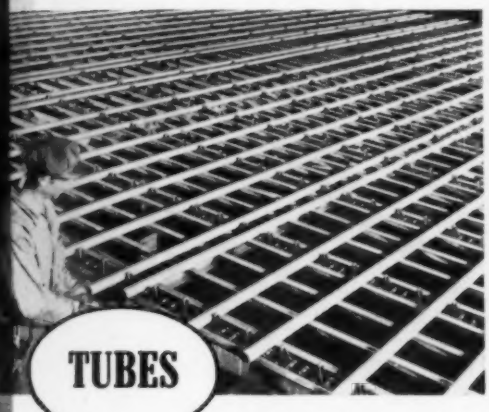
BILLETS

Thoroughly tested and dependable Link-Belt chain with pusher attachments transfers steel billets. This mill in the Pittsburgh area reports excellent performance.



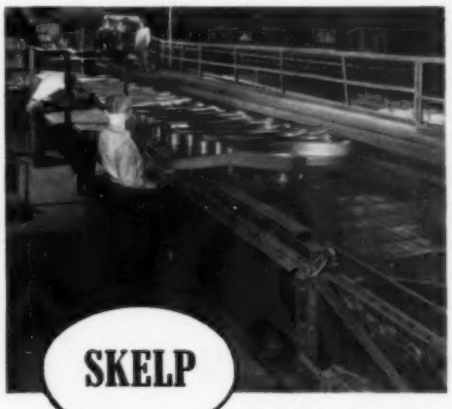
PLATES

Plates are transferred from hot run to cold run tables in this continuous hot strip mill. Employed are 51 strands of Link-Belt Class SS-4240 steel chain.



TUBES

Twelve endless strands of Link-Belt Class H pintle chain form a dependable conveying medium for modern pipe cooling rack. Link-Belt offers the right chain for every job.

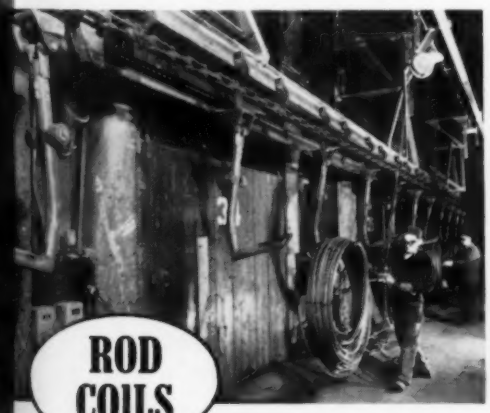


SKELP

Hot skelp is carried on its way to the reels by a Link-Belt steel apron conveyor. Conveyor is 108 in. wide and operates on 27 ft. 8 in. centers.

SCRAP

At this mill, scrap is handled on a mechanized Link-Belt system. By reducing crane and vehicle movement in the vicinity of the crews, safety is greatly improved.



ROD COILS

Cooled coils are tied as they move on an 850-ft. Link-Belt overhead trolley conveyor. This system handles the coils faster, with less hazard to workers.

MILL SCALE

Mill scale recovery was boosted from 250 to 475 tons a week by Link-Belt Straight-line Collectors. Sewer clogging and river pollution are eliminated.

LINK-BELT

MATERIALS HANDLING, PROCESSING & POWER TRANSMISSION EQUIPMENT

LINK-BELT COMPANY—Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle; Scarboro, Toronto and Elmira, Ont. (Canada); Springs (South Africa); Sydney (Australia). Sales Offices in Principal Cities. 13,288

RUST-OLEUM®

STOPS RUST!

Resists Rain, Snow, Heat, Fumes, Weathering, Salt Water, etc.

Rust-Oleum *saves* preparation, *saves* manhours! Just scrape and wirebrush to remove rust scale and loose particles . . . then brush Rust-Oleum 769 Damp-Proof Red Primer *directly over the sound rusted surface*. Rust-Oleum finish coatings in many colors, aluminum, and white provide *double protection*. Specify Rust-Oleum for new construction, maintenance, or re-modeling. Prompt delivery from Industrial Distributor stocks in principal cities.

RUST-OLEUM CORPORATION
2444 Oakton Street, Evanston, Illinois

FREE SURVEY: Ask a Rust-Oleum specialist to conduct a survey including actual applications, tests, and recommendations. No cost or obligation. See Sweets for nearest Rust-Oleum distributor or write for literature today.

There is only one Rust-Oleum . . .

Distinctive as your fingerprint, Rust-Oleum is an *exclusive formula* created and developed by a Master Mariner during more than 20 years of battling actual rust-producing conditions at sea.

It incorporates a specially-processed fish oil vehicle that will *dry*, is *odor-free*, and is formulated in many *colors*, *aluminum*, and *white*. Specify genuine Rust-Oleum. Accept no substitute.

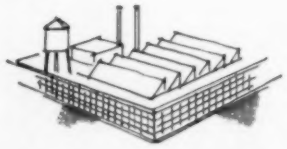
Practical, economical answer to your rust problems . . .

Sandblasting, chemical pre-cleaning and other costly preparations are not usually required as Rust-Oleum 769 Damp-Proof Red Primer may be applied *directly over sound rusted surfaces* after scraping and wirebrushing to remove rust scale and loose particles.

Brush, dip, or spray—available in many colors . . .

Beautify . . . as you protect with Rust-Oleum finish coatings available in a wide variety of colors. They incorporate the same basic rust-inhibiting vehicles and provide greater compatibility and *double protection*.

Proved throughout industry for over 25 years . . .



Leading companies throughout the world, in nearly every type of industry, have proved Rust-Oleum's capacity to resist rain, sun, snow, heat, fumes, salt water and salt spray, many acids and chemicals.

ATTACH TO YOUR LETTERHEAD—MAIL TODAY!

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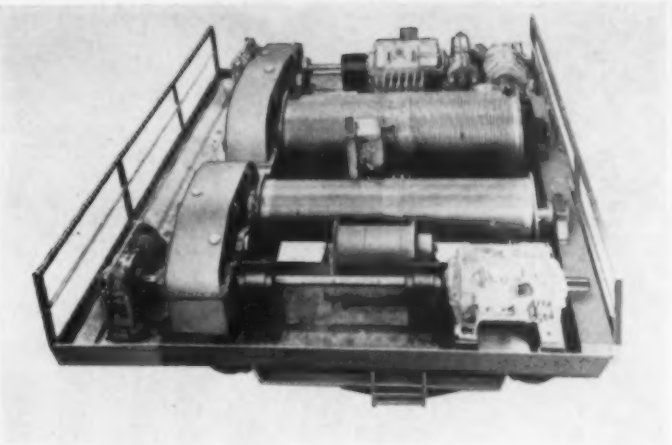
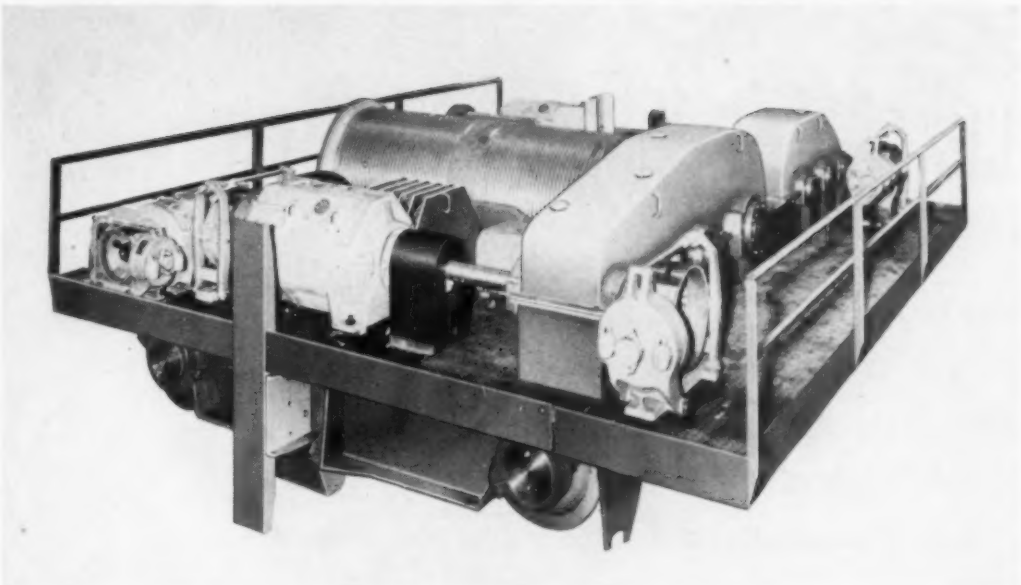
- ☐ Have a Qualified Representative Call
- ☐ Free Survey
- ☐ Complete Literature
- ☐ Nearest Source of Supply

to... A.I.S.E. Spec's.





STEEL MILL CRANES . . . *by "Shaw-Box"*

This 100-ton capacity crane trolley, with 25-ton capacity auxiliary hoist for a crane having a 100 foot span, was built to A.I.S.E. Standard No. 6 Specifications. When you buy cranes from "Shaw-Box" to these specifications and to your individual requirements, you pay less for engineering because "Shaw-Box" already has standard designs to A.I.S.E. Specifications for cranes from 15 to 100 tons capacity.

In "Shaw-Box" Cranes, you get cranes built exactly to specification plus the advantages of "Shaw-Box" engineering, manufacturing techniques, fine workmanship, performance, and the maintenance conveniences that have built an enviable reputation for all "Shaw-Box" equipment.

SEND ALL YOUR INQUIRIES FOR CRANES AND SOAKING PIT CARRIAGES TO "SHAW-BOX".

MAXWELL MANNING & MOORE MM&M TRADE MARK

"Shaw-Box" CRANES

MANNING, MAXWELL & MOORE, INC.

Muskegon, Michigan

Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, 'American' Industrial Instruments and Aircraft Products.

DREVER

Vertical Furn

Save time and cost in Continuous Strip Annealing

TIN PLATE
BLUE PLATE
GALVANIZING
SILICON STRIP
BRASS AND COPPER ALLOYS
NICKEL SILVER
NICKEL AND NICKEL ALLOYS
BERYLLIUM COPPER

Today no major steel mill can overlook the advantages of Drever's pioneer vertical furnace design for Continuous Strip Annealing. Definite performance records prove the product uniformity and cost-reducing factor of the Drever method in annealing and processing Tin Plate Strip, Blue Plate and other strip products. Drever equipment is designed for output up to 30 tons per hour of 30" widths low carbon steel.

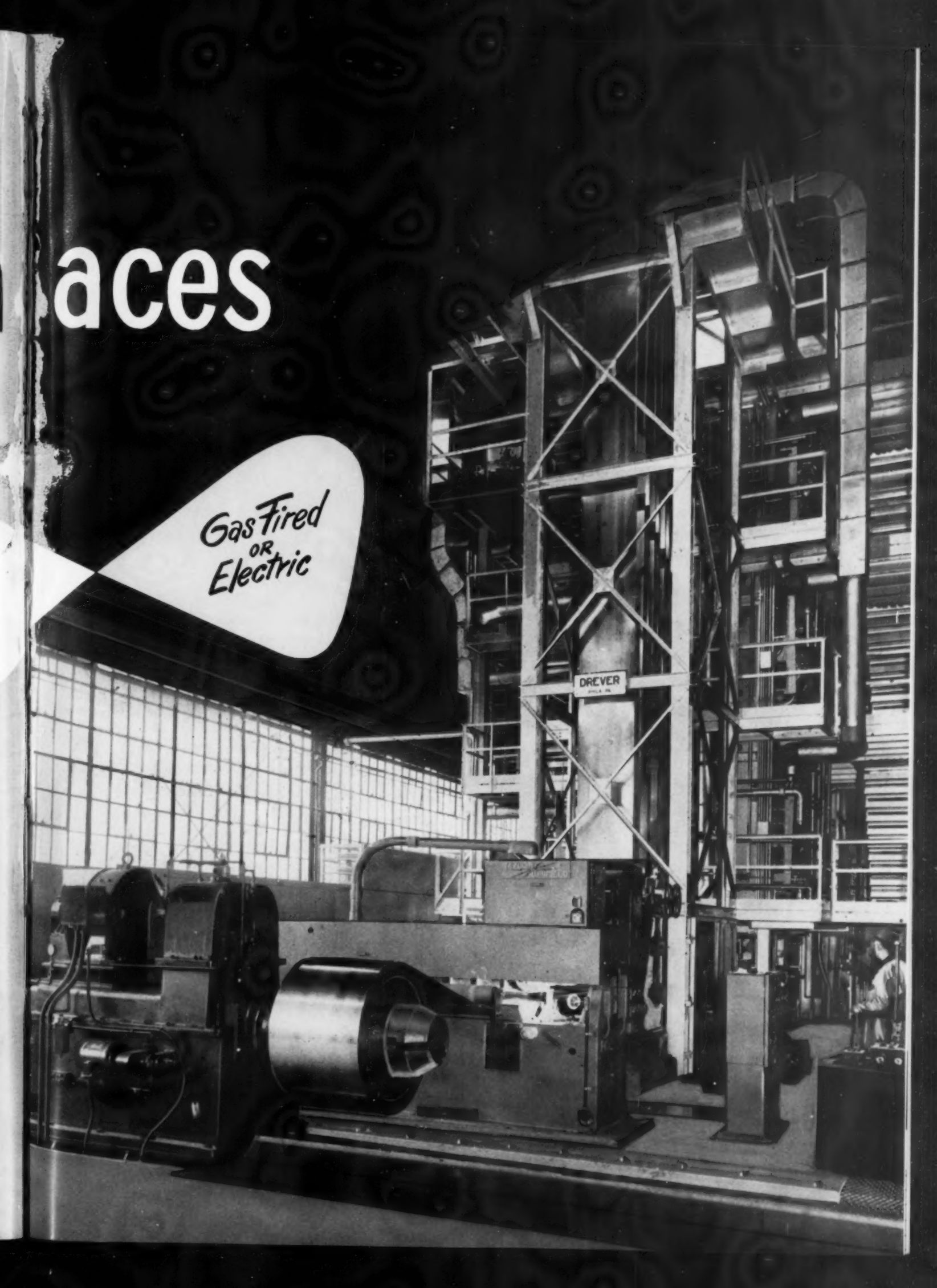
Let us prove the economy of Drever Vertical Furnaces.

DREVER CO.

730 E. VENANGO STREET • PHILADELPHIA 34, PA.

Pioneer Features

1. *Speeds up to 1,000 ft. per minute*
2. *Controlled strip tension, excellent tracking*
3. *Controlled heating and soaking time, regulated cooling rate*
4. *Uniform annealing from edge to edge and end to end as well as throughout the coil*
5. *Less floor space, reduced coil inventory*


aces
Gas Fired
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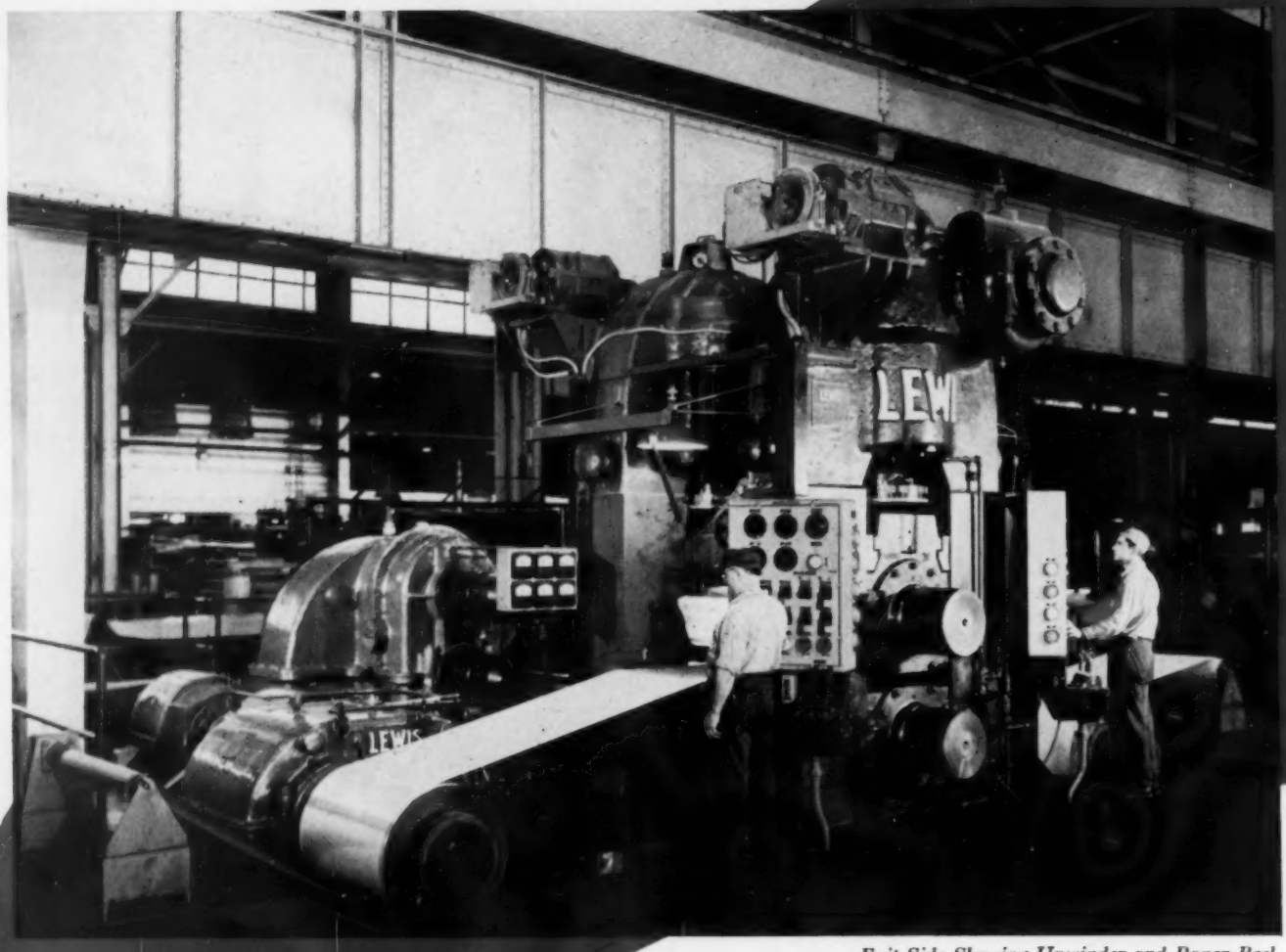
DREVER



Exit Side Showing Unwinder and Paper Reel

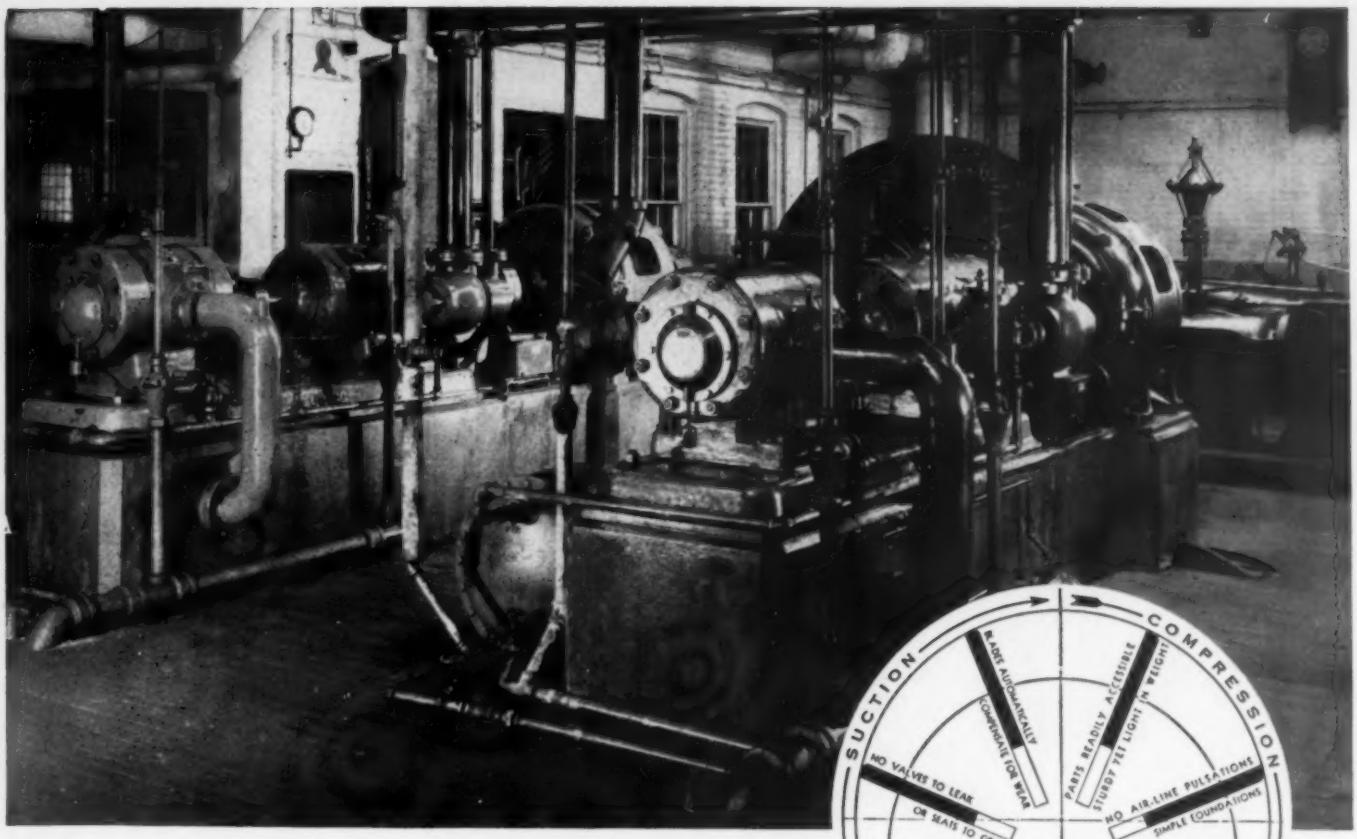
LEWIS 28" x 42" TWO-HIGH SKIN PASS MILL

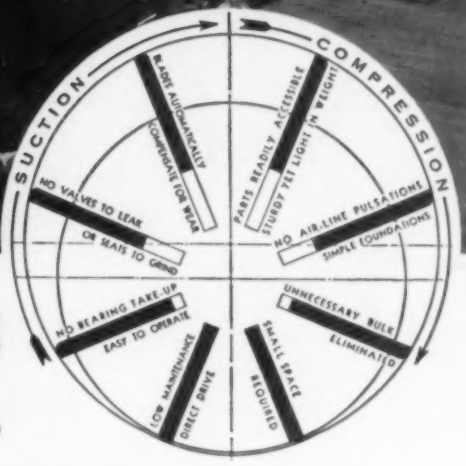
Entry Side Showing Drive

High productive capacity and extreme accuracy of gauge make this ultra-modern mill a year 'round money-maker. Like all Lewis Rolling Mill Equipment, it was designed by men who are "mill conscious"—who know the problems of both owners and operators. We welcome the opportunity to go into details at your convenience.

BLAW-KNOX

BLAW-KNOX COMPANY
LEWIS MACHINERY DIVISION
PITTSBURGH 22
PENNSYLVANIA





FULLER ROTARY AIR COMPRESSORS . . . WORK FOR SCOVILL

Long periods of continuous operation don't overtax these Fuller Rotary Compressors at Oakville Company Division, Scovill Manufacturing Company plant at Oakville, Connecticut, where two 850 c.f.m. two-stage compressors supply plant needs at 80-lb. pressure.

Endurance, plus maintained efficiency, are results of the rotary principle employed in these compressors. Elimination of reciprocating parts does away with flow pulsations, cuts down on vibration and need for take-up of bearings. Another feature of interest to cost-conscious engineers is the limited maintenance required by Fuller Rotary Compressors—rotor, blades, and bearings are the only moving parts.

Because these compressors do not require valves, top overall efficiency is maintained at all times—no capacity is lost around leaking valves, no time lost to grind seats. Fuller compressors are designed to operate at common electric motor and internal-combustion engine speeds.

You'll find these compressors stay on the job, operate with sustained high efficiency and require little maintenance. If your plant requires air in volume, it will pay you to investigate the advantages of Fuller Rotary Compressors. A Fuller engineer will be glad to discuss them with you.

Fuller

FULLER COMPANY, Catasauqua, Pa.

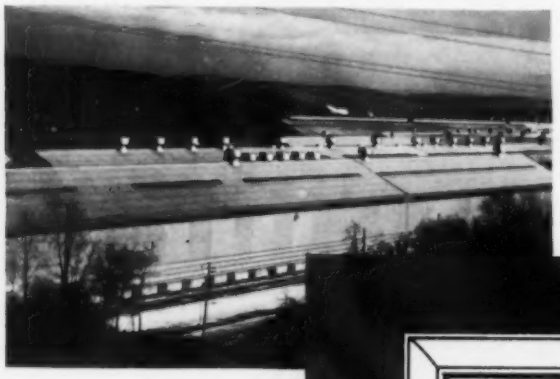
Branch offices

Chicago—San Francisco—Los Angeles—Seattle—Birmingham

C-223
1863

PIONEERS OF HIGH-EFFICIENCY VANE-TYPE ROTARY COMPRESSORS

IRVIN WORKS, U.S. STEEL—PITTSBURGH, PA.—*Another one of the more than 11,000 successfully completed electrical contracting jobs engaged in by F&M in the past 35 years.*



Another Electrical Installation by

FISCHBACH AND MOORE

INCORPORATED

"Integrity's Signature..."

Our performance on jobs of the calibre of U. S. Steel's, Irvin Works – as in countless other jobs over the past 3 decades – is indicative of our acknowledged reputation as one of the leaders in the field of electrical contracting. Whatever your project, F and M's vast fund of experience means your worries end when our work begins.

FISCHBACH AND MOORE

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ELECTRICAL CONTRACTORS

FROM COAST TO COAST *An organization that has to its credit every conceivable type of electrical installation.*

COMPLETE ORGANIZATIONS AT: *New York, Atlanta, Dallas, Houston, Los Angeles, San Francisco, Detroit, Chicago, Pittsburgh.*

HOT STRIP DESCALING

Thin jets of water strike with tremendous force against sheets of steel. Harmful scale is dislodged, broken up, carried away. The steel passes on—and its producer is assured of higher quality, more accurate gauge and better surface finish.

Such is the story every day, in one steel plant after another, wherever an *Aldrich Descaling System* is on the job.

In these plants Aldrich Direct Flow Pumps and Spray Nozzles, tied together in hard-hitting teams, do their jobs quickly and efficiently. The pumps build up high water pressures to nozzles, which, in turn, are designed to produce knife-edged lines of water with an impinging force equal to 95% of the potential energy supplied to the nozzle orifices. This powerful action breaks the scale in a fraction of a second; the deflected stream of water washes away the loose scale.

The jet action and striking force developed by Aldrich Patented Spray Nozzles give far more effective descaling than nozzles which produce jets of equal force but with larger impinging area . . . a claim proven in hot strip as well as billet descaling! High efficiency of cutting spray force results in thorough descaling *without* excessive cooling due to overabundant use of water.

There's an Aldrich Descaling System—or Pumps or Spray Nozzles—to meet *your* particular needs. Write us today for complete information.

The Aldrich Pump Company

21 PINE STREET • ALLENTOWN, PENNSYLVANIA

Representatives in Principal Cities

ALDRICH

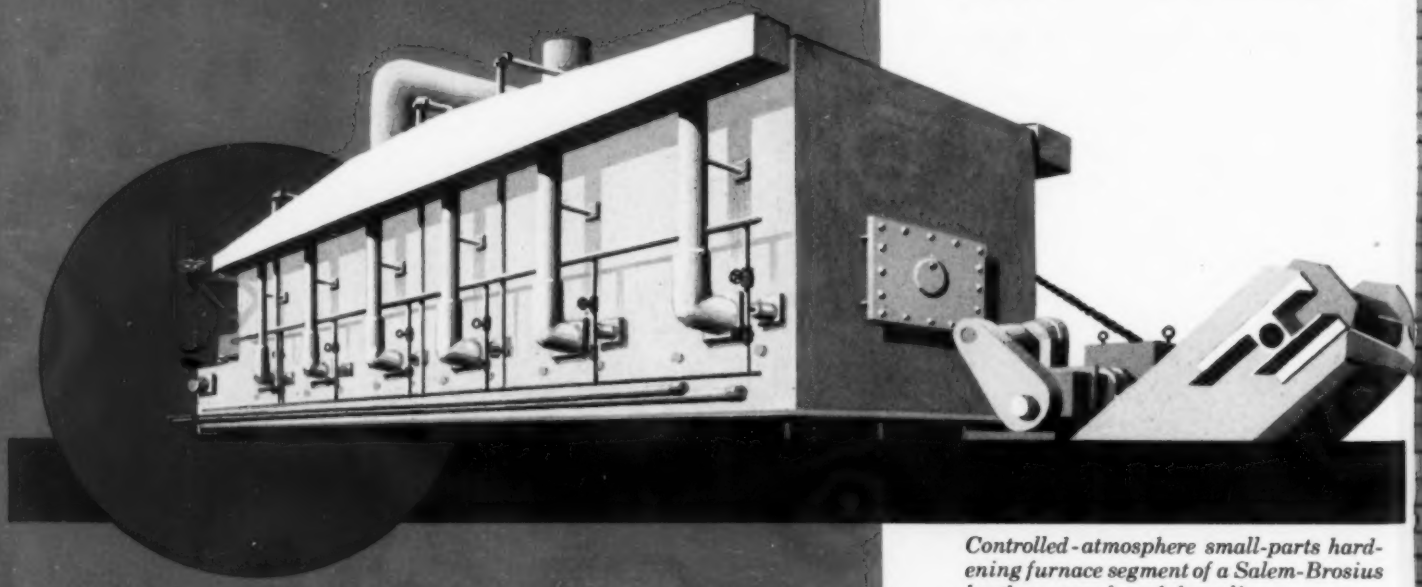
Salem-Brosius has a

bad habit

that means profit to you!

Salem-Brosius has the unfortunate habit of going to the extra trouble of engineering more quality into its furnaces than the application might indicate. Unfortunate for Salem-Brosius, but fortunate for you. Prices being equal, you, as a customer, can hardly lose from an extra measure of good design and sturdy construction that assures you greater production, longer life, and easier operation.

Take the case of the controlled-atmosphere small-parts hardening furnace shown here, for which Salem-Brosius is justifiably well-known. Users find that fast precise heating, complete atmosphere control, and rapid and high capacity materials handling mean better production. Why not take advantage of our bad habit of extra quality. Send us an inquiry for this or any other type of heat-treating furnace now.



Controlled-atmosphere small-parts hardening furnace segment of a Salem-Brosius harden, quench and draw line.

SALEM-BROSIUS, INC.

Sales and Executive Offices: 248 Fourth Avenue, Pittsburgh 22, Pa.

for NATIONAL TUBE COMPANY

Square D controls operate the double spindle coupling screw-on machines for the No. 4 seamless tube mill at the National Tube Company, Lorain Works. These panels illustrate typical tailor-made construction for the specific machines. They incorporate D.C. mill auxiliary control for D.C. motors as well as A.C. control for a hydraulic system involving many electrically operated valves.

Electrical controls for mill machinery become more complex with the demand for more automatic operation and faster production. This trend emphasizes the need for careful circuit design and complete lines of dependable, trouble-free component devices such as Square D has available.

A nation-wide field engineering organization facilitates and coordinates design planning between the user, the machinery builder and the Square D factory. Trained engineers, located in principal cities, are at your service.

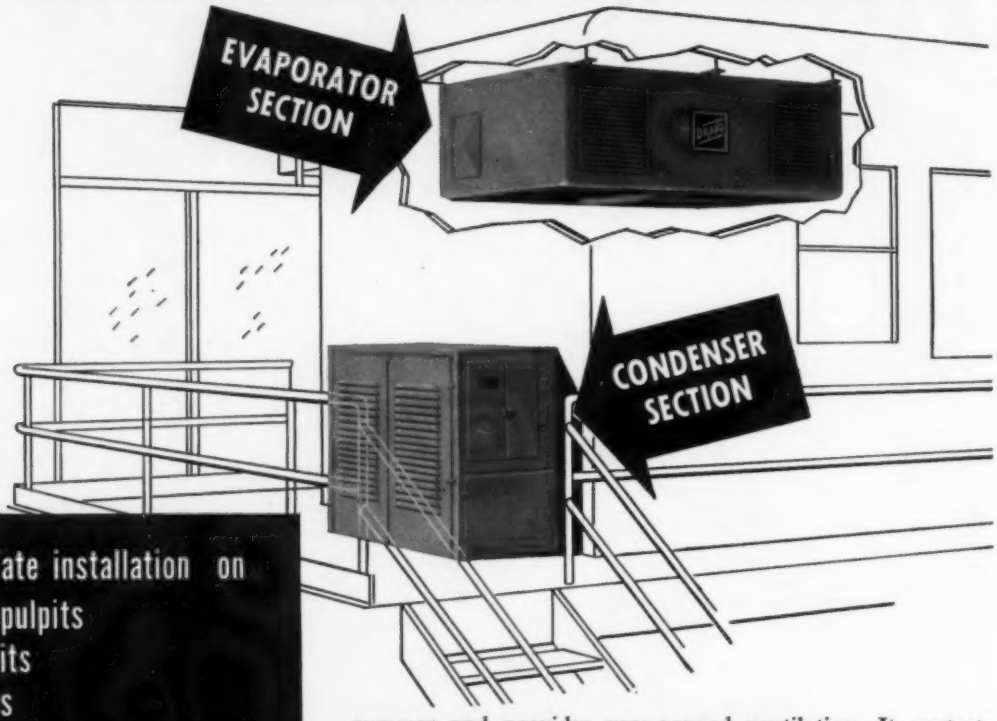
Controller above operates double spindle coupling screw-on machines at National Tube Company, Lorain Works.

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS

SQUARE D COMPANY

1903 · 50 YEARS OF DESIGN LEADERSHIP · 1953

Announcing...
The NEW DRAVO
PULPIT AIR CONDITIONER



. . . available for immediate installation on
- blooming mill pulpits
- strip mill pulpits
- rod mill pulpits

and other steel mill control locations where heat, dirt and fumes create working hazards

The new Dravo Pulpit Air Conditioner—latest addition to Dravo's complete line of industrial air conditioning units—is especially built for pulpit installations. The evaporator section is floor- or ceiling-mounted inside the pulpit along with a suitable cabinet which contains all controls. The condenser section is located adjacent to the pulpit wherever convenient. The two sections are joined by refrigerant piping. Either water or air can be used as the refrigerant.

Thermostatic Control for Year-around Air Conditioning

The Dravo Pulpit Air Conditioner is thermostatically controlled to maintain 80° to 85° F temperature in the pulpit in summer when ambient temperature is 175° F; and 68° to 72° F in winter with an ambient temperature of 0°F.

The Pulpit Air Conditioner filters the air, removes dust, dirt, fumes and gases; heats the pulpit in winter, cools it in summer and provides year-around ventilation. It protects pulpit operators' health, makes them more comfortable and efficient and enables them to work longer periods of time.

Easy Installation, Long Service Life

The Dravo Pulpit Air Conditioner can be easily installed by Dravo personnel without interruption of work operations. Each unit is factory-assembled, pre-tested and is ruggedly constructed for years of service. All parts are readily accessible for easy maintenance.

Write Today for Complete Information

Get the full story on Dravo's Pulpit Air Conditioner. Write—or phone—the nearest Dravo Office and ask our representative to call.

DRAVO CORPORATION

Air Conditioning Department
Fifth and Liberty Avenues, Pittsburgh 22, Penna.

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Patent Reviews

By MELVIN NORD
Patent Attorney
Detroit, Mich.

. . . . copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C., at 25 cents each . . . . patents reviewed cover period May 19 through June 9, 1953 . . . . .

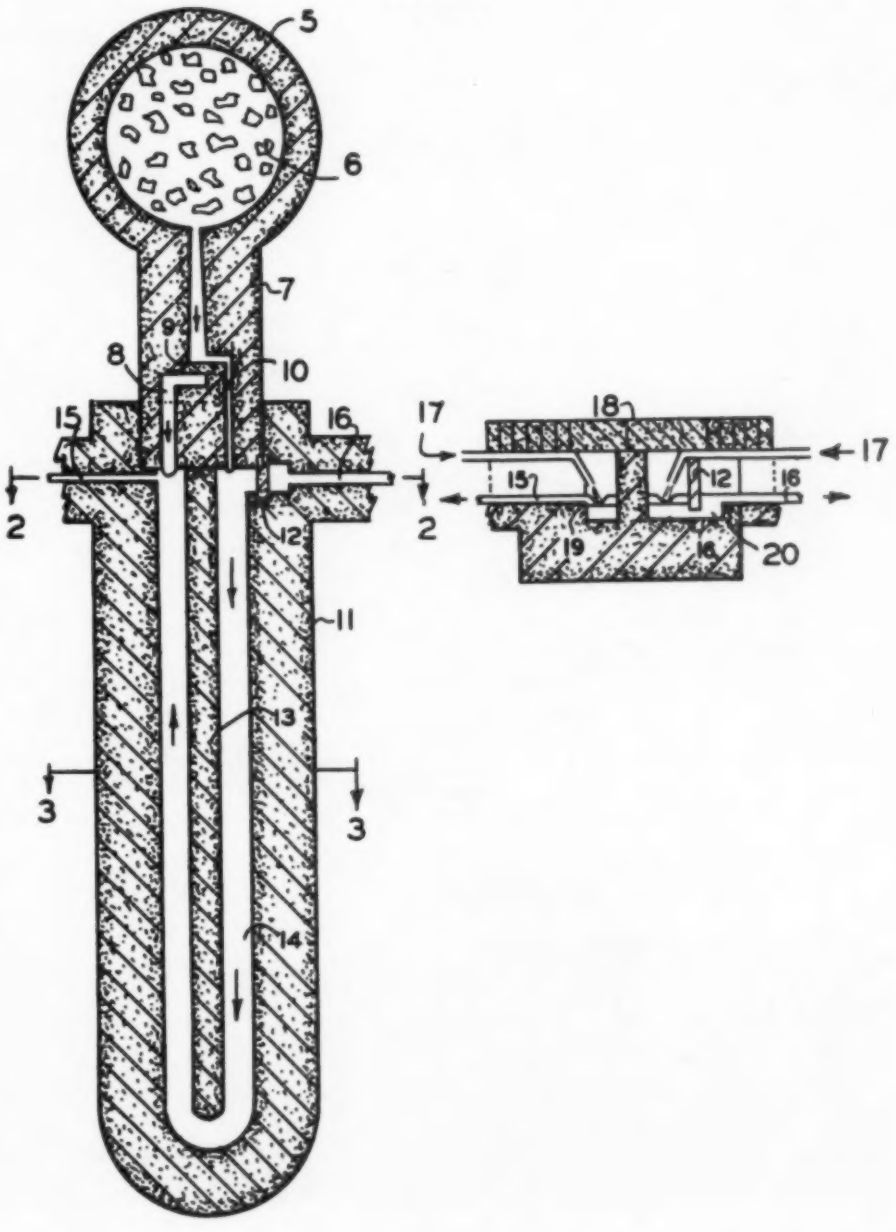
CONTINUOUS CUPOLA-BESSEMER PROCESS

▲ Steel scrap and pig iron are melted continuously in a cupola and refined in a continuous bessemer-type process in U. S. 2,639,984, issued May 26, 1953. The inventor is James Fernando Jordan. An earlier patent of the inventor, U. S. 2,595,792, is also of interest in this connection.

When steel scrap and pig iron are melted in a coke-fired cupola, a high-sulfur, low-phosphorus material is produced, which cannot be refined satisfactorily by the conventional bessemer process. Furthermore, the strongly oxidizing action of the melting process results in the wastage of a considerable amount of the metallic charge. In the method described in the present patent, both these difficulties are overcome, and the entire process is operated in a continuous manner. The iron lost to the cupola slag is returned to the metallic state by using the molten basic slag that is produced in the (basically-lined) cupola as the reagent slag in the bessemer-type process. Thus, the iron oxide content of the cupola slag carries out part of the refining operations, in turn reducing the iron oxide to iron, which joins the refined metal.

The operation is illustrated in Figures 1, 2 and 3. A basically-lined cupola 5 is fired with coke 6, the charge of slag-forming constituents into the cupola being such that the slag resulting from the melting operation is basic. The cupola is arranged

Figure 1



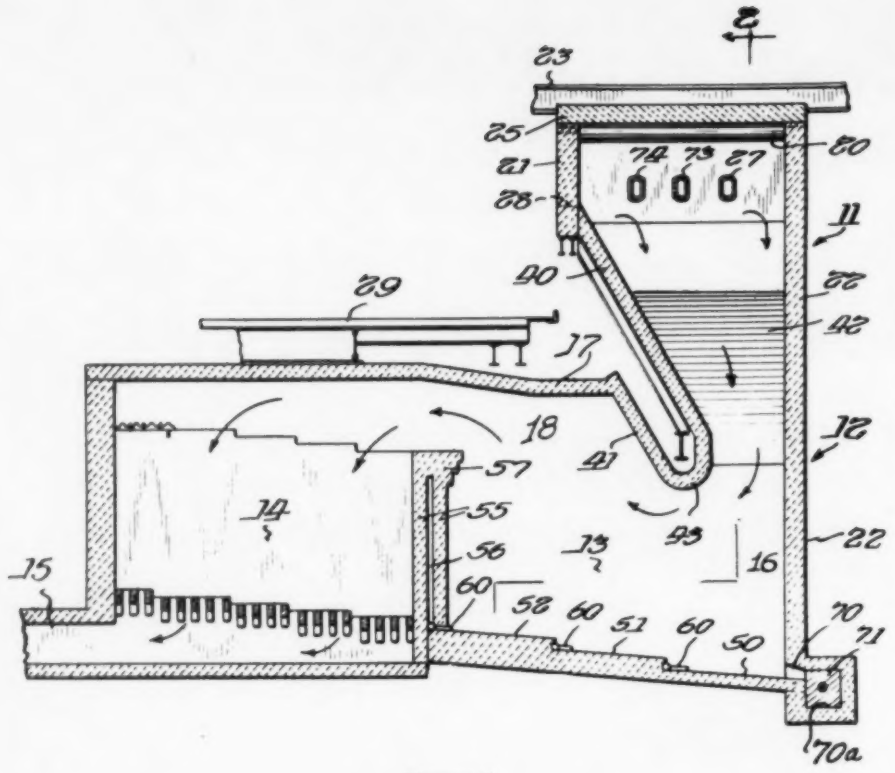
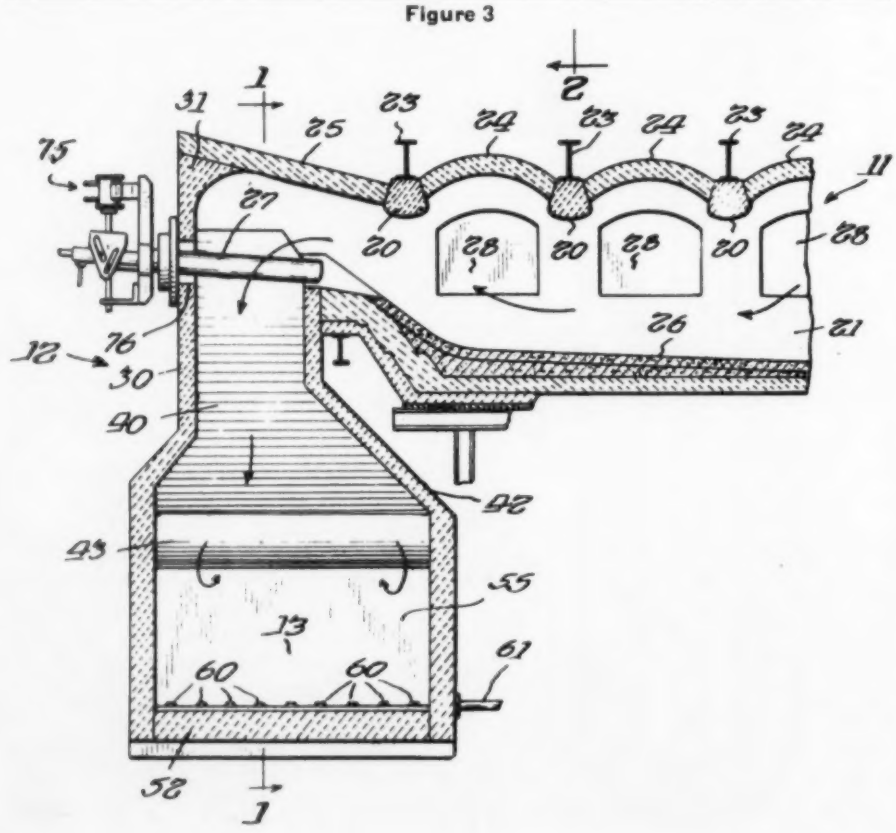


Figure 2

to tap continuously into spout 7, which retains a pool of slag and metal while continuously separating the floating slag stream 10 from the underlying metal stream 8, an underflowing skimming dam 9 being provided for this purpose. The metal stream then flows into one end of a U-shaped refining trough 11, and the slag stream enters the other end. The two streams flow countercurrent to each other, and are separated at opposite ends, as shown in the upper right sketch. A series of air jets impinge on the streams along the length of the refining trough, resulting in a bessemer-type process. The slag is useful in desulfurizing the metal, as well as in oxidizing it. The air jets not only oxidize the FeO content of the slag to Fe_2O_3, but also oxidize the sulfur content of the slag to SO_2. The Fe_2O_3 diffuses into the iron, thereby aiding in the oxidation of carbon and impurities; the SO_2 is liberated as a gas, thereby permitting diffusion of sulfur from the steel to the slag.

It is claimed that as much as 50 per cent steel scrap can be used in this process, while producing continuously a low-sulfur, low-phosphorus steel.

Figure 3



TREATMENT OF SPENT PICKLE LIQUOR

In U. S. 2,639,222, issued May 19, 1953 to Edwin S. Tanski, assigned to Marblehead Lime Co., an improved method of precipitating ferrous salts from spent pickle liquor is disclosed.

The liquor is first neutralized with a lime slurry in the conventional manner, precipitating a mixture of calcium sulfate and ferrous hydroxide. Only a slight excess of lime is used. The resulting slurry is then partially de-watered to form an effluent containing traces of calcium sulfate, and a sludge which has filtering characteristics superior to those produced by the conventional precipitation process. Part of the effluent is then recycled to a stage where the lime is slaked; slaking with such a solution instead of with water has been found to be advantageous in obtaining the easily filterable iron precipitate. Furthermore, the problem of disposing of the effluent is greatly decreased, since its volume has been decreased.

CHROMIUM ADDITIONS TO STEEL

Reduction of the time required for chromium addition, increased recovery of chromium in the steel, and the addition of the chromium in the ladle are made possible by the means described in U. S. 2,639,232. The patent was issued May 19, 1953 to James C. Vignos and assigned to Ohio Ferro-Alloys Corp.

The addition material used is a ferro-chromium alloy containing 5 to 70 per cent chromium, up to 7 per cent carbon, up to 50 per cent silicon, and the balance substantially iron.

THIS WF WIRE FLATTENING TEAM

Close-up of a Waterbury Farrel winder at the delivery end of a WF Tandem Mill. Winder is provided with pneumatic clamping of reels. It has three adjustments for width of wire and width and positioning of drum or spool.

. . . SQUEEZES "DOWN-TIME", TOO

This complete Waterbury Farrel mill package includes 10" and 8½" Tandem Wire Flattening Mills, power driven double head Pay-off, Edger, Winder, footage counter, continuous thickness and width gauges and automatic electrical synchronizing control. Other WF tandems with up to five mills available.

Modern Waterbury Farrel Mill Design Insures High Production Plus Precision . . . Minimizes "Down-Time"

Here are some reasons why Waterbury Farrel Wire Flattening equipment can give you *more continuous*, high speed, precision production.

- Loading payoff and motor driven screwdowns for mills and edgers facilitate threading of wire with minimum effort and time.
- To protect precision operation, soluble oil is circulated internally and externally on the rolls and into coolant enclosures where wire is submerged. A refrigeration system maintains the coolant oil temperature at approximately 70° while a flotation unit keeps it clean and fresh. In addition, high speed mills also have a self-contained, automatically-filtered circulating mineral oil lubrication system for roll necks and drives.
- Transparent lucite covers at vital lubrication points such as gear cases and universal joints make it easy to check lubrication at a glance.
- Anti-friction bearings are used for all rotating members including the winder shaft. High precision anti-friction bearings are used on roll necks and edger arbors. This, combined with precision fitting of component parts enables WF mills to maintain tolerances well inside commercial allowance.
- Tungsten carbide ring rolls permit rolling the toughest alloys and increase roll life.
- Electric control keeps wire tension constant. Dancer rolls are used for fine wire.

Waterbury Farrel designs and builds a wide range of wire flattening mill equipment to suit specific requirements. Various sizes and combinations of single and multiple mill stands with auxiliary equipment are available for flattening ferrous and non-ferrous wire from the smallest diameters to 1" diameter and more. Speeds range up to and above 2500 FPM.

Write for further information.

WATERBURY FARREL FOUNDRY & MACHINE CO.
WATERBURY 20, CONN.
***Sales Offices:* Chicago, Cleveland, Millburn, N. J.**

WATERBURY FARREL FOUNDED 1851

A FEW OF THE MANY TYPES OF METAL WORKING MACHINERY MADE BY WATERBURY FARREL

MILL MACHINERY—Rolling Mills: Strip, Rod, Wire Flattening, (For Ferrous and Non Ferrous Metals) • Also Slitters • Straighteners • Cut-off Saws • Coilers • Winders, etc. *WIRE MILL EQUIPMENT*—Continuous Wire Drawing Machines (Upright Cone and Tandem) • Wire Flattening Mills • Chain Draw Benches • Pointers Swagers • Bull Blocks • String-up Machines • Spoolers, etc. *COLD PROCESS BOLT & NUT MACHINERY*—Headers (all types) • Rivet Machinery • Trimmers • Thread Rolling Machines • Slotters • Nut Formers and Tappers, etc. *POWER PRESSES*—Crank, Cam and Toggle; also Rack and Pinion Presses • Eyelet Machines Multiple Plunger Presses • Horizontal and Hydraulic Presses, etc.

WF-9

The material is crushed to about ¼ in. to ½ in. size and is coated with a wetting agent, thus facilitating solution in molten iron or steel. The wetting agent can consist of any material which will lower the surface tension of the molten slag or the metal, such as alkali-metal nitrates, chlorates, etc.

MANUFACTURE OF COKE

High-volatile caking coals and petroleum coke are blended to produce mixtures for use in metallurgical coke manufacture in U. S. 2,640,016, issued May 26, 1953 to Samuel W. Martin, and assigned to Great Lakes Carbon Corp.

The petroleum cokes used are produced by non-catalytic pyrolysis of petroleum hydrocarbons, such as topped crude oils, and they have 14-35 per cent volatile content. Between 5 and 25 per cent of petroleum coke may be used in the mixture.

MEANS FOR SEPARATING SOLIDS FROM EXHAUST GASES IN OPEN-HEARTH FURNACES

U. S. 2,640,692, issued June 2, 1953 to Jay J. Seaver, contains means for deflecting the exhaust gases from the open hearth to a regeneration chamber by way of a slag chamber, so that the solids entrained in the exhaust gases are deposited in the slag chamber for periodic removal.

As shown in Figures 2 and 3, hot gases created by the burners 27 and coming from the uptake 12 at the end of the furnace hearth sweep over the hearth bath on the hearth floor 26. The cross baffles 20 in the roof break up the upper layers of the hot gas stream, providing an air pocket underneath each transverse arch 24, thus prolonging the life of the roof. The baffles are made of refractory material which can withstand a great amount of heat over a relatively long time. Repairs can be made on an individual arch when necessary.

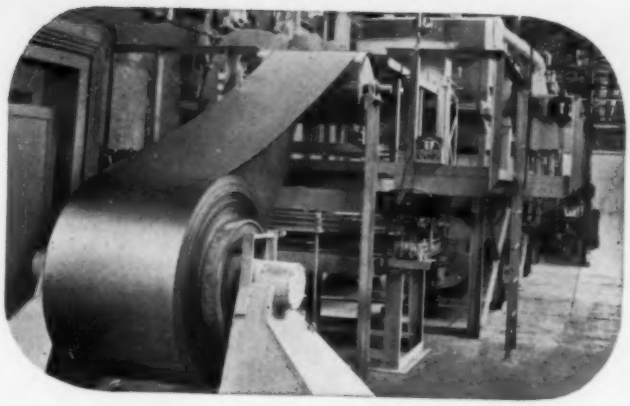
The deflector structure (walls 40, 41 and 30, 42) gradually flattens the stream of exhaust gases and at the same time adjusts it to the width of the slag chamber 13. The entrained solids are thus propelled at a high velocity at an angle against wall 22 of the slag chamber over its entire width. When the gas enters the slag chamber it suddenly expands into the rear of the chamber, thus suddenly reducing the velocity of flow and permitting the heavy entrained solids to continue downward to the stepped floor of the slag chamber, where they are deposited. The purified gas stream, substantially free of solids, leaves the slag chamber and goes to the checker chamber 14. The solids are removed from the slag chamber before the periodic reversal of the operating cycle through a slotlike opening 70 extending across the width of the slag chamber. The ram 71 is withdrawn when removal of the slag is to be effected, and steam is injected in the nozzles 60 in the rear of the floor of the slag chamber, forcing the accumulated solids toward the discharge point.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or Assignee
2,638,646	5/19/53	Centrifugal casting machine	George A. Rubissow
2,638,665	5/19/53	Method of welding stainless steel	Standard Oil Development Co.
2,638,818	5/19/53	Wire finishing method and apparatus	Armco Steel Corp.
2,638,889	5/19/53	Heating elements for heat-treating furnaces	Doris B. Dow
2,638,909	5/19/53	Quench tank for heat-treating	International Harvester Co.
2,639,047	5/19/53	Conveyor apparatus for heat-treating metal parts	Harold N. Ipsen
2,639,138	5/19/53	Heat-treating apparatus	Doris B. Dow
2,639,245	5/19/53	Formation of a sulfide coating on steel	Parker Rust Proof Co.
2,639,304	5/19/53	Removal of paraffins from coke oven distillates	Jones & Laughlin Steel Corp.
2,639,610	5/26/53	Furnace atmosphere indicator for oxidizing or reducing power	Charles Engelhard, Inc.
2,639,619	5/26/53	Relief device for power press brakes	Columbia Machinery & Engineering Corp.
2,639,985	5/26/53	Bearing steels	United States Steel Corp.
2,640,541	6/ 2/53	Power stop device for power presses	Buffalo Forge Co.
2,640,591	6/ 2/53	Automatic handling and hardness testing machine	Eaton Manufacturing Co.
2,640,773	6/ 2/53	Titanium base alloys	Allegheny Ludlum Steel Corp.
2,640,792	6/ 2/53	Removing surface defects of high-chromium ingots by remelting in an inert gas atmosphere	Union Carbide & Carbon Corp.
2,640,807	6/ 2/53	Treatment of acid and cyanide wastes	Cyrus W. Rice
2,641,064	6/ 9/53	Rotary cooling apparatus	United States Steel Corp.
2,641,456	6/ 9/53	Regenerative heat recovery apparatus	William E. Schmertz
2,641,461	6/ 9/53	Side-blow bessemer converter	Crucible Steel Corp. of America
2,641,525	6/ 9/53	Method of pouring steel ingots	United States Steel Corp.
2,641,540	6/ 9/53	Ferrous base chromium-nickel-titanium alloy	Allegheny Ludlum Steel Corp.
2,641,559	6/ 9/53	Bath for cleaning and descaling ferrous articles	United States Steel Corp.
2,641,575	6/ 9/53	Coke oven buckstay structure	Carl Otto
2,641,621	6/ 9/53	Submerged resistor type induction furnace	Albert E. Greene

If You Are Annoyed by having someone else borrowing your magazine when you want it . . . . . .

Get him to join the AISE.



EF CONTINUOUS STRIP LINES — for annealing, galvanizing, aluminizing, etc. This combination gas-fired and electric unit provides flexibility in controlled heating, soaking and cooling, for producing various surface and metallurgical conditions on ferrous and nonferrous strip. Built by The Electric Furnace Co., Salem, Ohio.

EF CONTINUOUS FURNACES are built in many sizes and types for processing wire, sheet, castings, stampings, strip, tubing and many other products. This EF gas-fired radiant tube special atmosphere furnace bright normalizes 3000 lbs. steel tubing per hour. Built by The Electric Furnace Co., Salem, Ohio.

EF builds Gas-Fired, Oil-Fired and Electric Furnaces for these and other heat treating operations

● EF engineers specialize in designing and building production furnaces — continuous and batch types — including roller hearth, roller rail, chain belt, wire belt, slot and tube conveyor types, reciprocating, rotary, car, bell, pit and other designs; complete with special atmosphere producers, and time and labor saving material handling equipment as required.

Reflecting more than 30 years of continuous research and experience, and outstanding engineering accomplishments, EF furnaces combine high heating efficiency, accurate automatically controlled cycles, and advanced designs that minimize maintenance, assure economy of operation, high hourly output and uniformity of product.

Submit your production furnace problems to ***experienced engineers — it pays.***

AGING
ANNEALING
ALUMINIZING
BRAZING
CARBON RESTORATION
CARBURIZING
CERAMIC DECORATING
DRAWING
GALVANIZING
HARDENING
HOMOGENIZING
MALLEABLIZING
NORMALIZING
NITRIDING
SINTERING
SOLUTION TREATING
SPECIAL ATMOSPHERE TREATMENTS AND OTHER PROCESSES

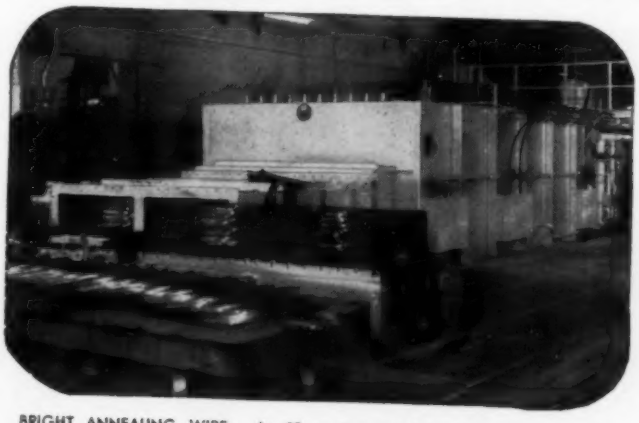
EF

THE ELECTRIC FURNACE CO.

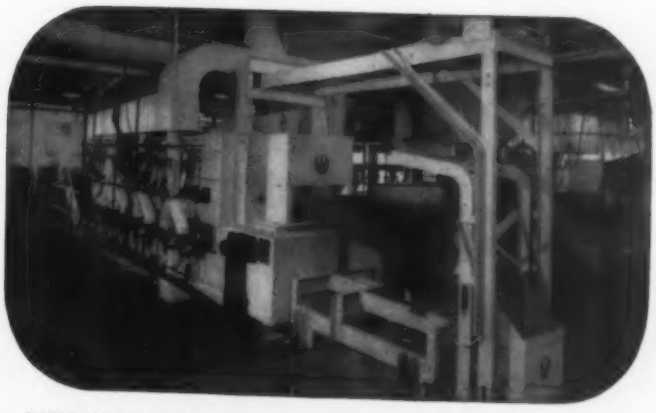
GAS FIRED, OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS PRODUCT OR PRODUCTION

Salem - Ohio

Canadian Associates • CANEFCO LIMITED • Toronto 1, Canada



BRIGHT ANNEALING WIRE. An EF continuous bright annealing furnace in which the wire is conveyed through the various zones on two parallel rows of bulkhead type trays. This unit has convection cooling and handles 2500 net lbs. of wire per hour. Built by The Electric Furnace Co., Salem, Ohio.

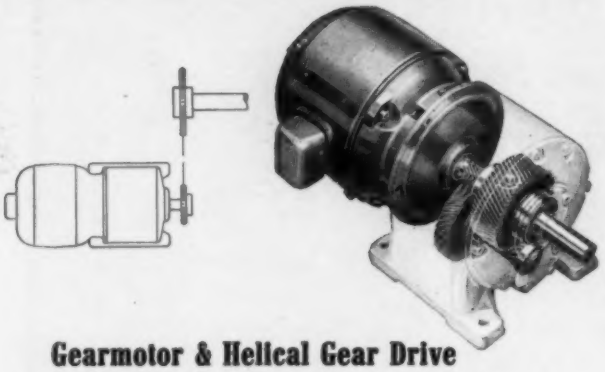


HARDENING SMALL PARTS — CONTINUOUSLY. EF chain belt conveyor furnaces are unsurpassed for uniform, low cost, scale-free hardening, carbon restoration and non-decarb heat treating. 11 sizes. Capacities from 175 to 2000 lbs. per hour. Built by The Electric Furnace Co., Salem, Ohio.

LINK-BELT makes even your most complex speed reduction jobs *simple*

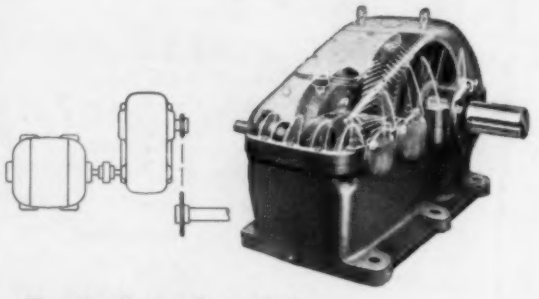
Worm Gear Drive

WORM GEAR and P.I.V. variable speed drives are shown direct-coupled. Link-Belt worm gear drives are available in 3.1:1 to 8000:1 reduction ratios — 1400 to 123,000 in. lbs. torque — 0.22 to 564 output shaft rpm. Ask for Book 2324A.



Gearmotor & Helical Gear Drive

GEARMOTOR is shown with roller chain drive. Link-Belt Helical Gear Drives, Gearmotors and Motogears are available in 6.2:1 to 292:1 reduction ratios — 1 to 30 hp — 6 to 280 output shaft rpm. Ask for Books 2247 and 2451.



Herringbone Gear Drive

HERRINGBONE GEAR DRIVE is shown connected by flexible coupling to motor and with roller chain takeoff. Link-Belt Herringbone Gear Drives are available in 2.84:1 to 326:1 ratios — 0.4 to 2480 hp — 2.2 to 623 output shaft rpm. Ask for Book 2519.

Get the proper drive combination that best meets your overall requirements from a broad line

ONLY Link-Belt can offer you such a broad selection of helical, herringbone and worm gear drives . . . plus the pre-engineered correlation of all its other power transmission equipment. This exclusive combination not only simplifies even the most complex problem — it actually cuts your costs. Here's how:

(1) You save on installation. Dimensions of all components — chains, sprockets, couplings, bearings — are correlated with the reducer's. There's no alignment problem . . . no need to exchange drawings with other suppliers.

(2) You save on operating costs. Power consumption is lower because overall efficiency is assured. And maintenance costs go down when you rely on quality-built Link-Belt equipment.

Let a Link-Belt representative help you figure the best combination for your speed reduction requirements. You'll find it pays to make the nearby Link-Belt sales office or distributor your power transmission headquarters.

LINK-BELT

ENCLOSED GEAR DRIVES

13,128

LINK-BELT COMPANY: Plants: Chicago, Indianapolis, Philadelphia, Colmar, Pa., Atlanta, Houston, Minneapolis, San Francisco, Los Angeles, Seattle, Toronto, Springs (South Africa), Sydney (Australia). Sales Offices, Factory Branch Stores and Distributors in Principal Cities.

For Fast, Efficient, *Low-Cost* Pickling

Install a WELDCO Mechanical Tube Pickler As Youngstown Sheet & Tube did at *Indiana Harbor*

THE WELDCO Tube Pickler combines the advantages of extra mechanical agitation and fast chemical action. Uniform descaling is accomplished by alternately raising and lowering the load on spreaders. This rolling, tumbling, spreading action speeds up descaling; then the tubes are tilted, and the liquid carries away all loose scale, **completely** flushing out each tube. This fast inside flushing action cuts pickling time to a minimum . . . increases efficiency. With this in mind, and to insure adequate capacity for their new pipe mill, The Youngstown Sheet & Tube Co. ordered WELDCO Mechanical Tube Picklers.

Four 10-ton Picklers were installed in their new Indiana Harbor pipe mill, making it one of the largest pipe pickling installations in the country. The WELDCO Units in this plant handle pipe from 10′ to 23′6″ long, provide fast, efficient flushing action, with better finish, uniform pickling and descaling, and big savings in manpower, maintenance and steam consumption.

It will pay you to get all the details on WELDCO's complete line of Mechanical Picklers—available for Bars, Tubing, Coils and Sheets. Contact us for complete information, and for engineering service on your entire pickling line.

THE YOUNGSTOWN WELDING & ENGINEERING COMPANY
3719 OAKWOOD AVENUE · · YOUNGSTOWN 9, OHIO

Modern Safeguards—Brink's for Money, Bailey for Process Materials

Are Your Process Materials Guarded As Well?

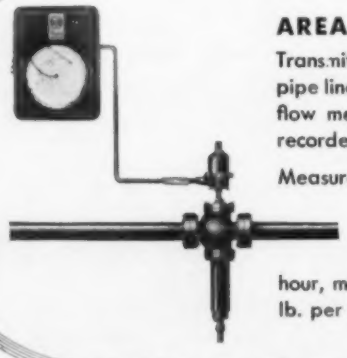
HERE'S HOW TO PREVENT SPOILAGE AND WASTE . . .

TO avoid waste of valuable process materials and finished products, process rates and conditions must be accurately measured and controlled. That's where Bailey Meters, Analyzers and Controllers can help you to improve the efficiency of your plant.

Take flow for instance. Bailey Meter Company offers a complete line of flow measuring and controlling equipment for applications ranging all the way from high pressure steam to low pressure gas. We measure flow in pipes, open channels, ducts, furnaces, smelters, kilns, ovens, dryers.

When you call Bailey Meter Company, you get the help of years of experience as well as recommendations from a wide selection of measuring and controlling devices.

Your local Bailey Engineer is as near as your telephone. He has the experience and the equipment necessary to set up an effective guard for your process materials. P-26



AREA TYPE FLOW METER

Transmitter goes into 1, 2 or 4 inch pipe line like a valve and transmits flow measurements electrically to recorder in remote location.

Measures oil and other clear liquids under static pressures up to 600 psi. Minimum range 0 to 1200 lb. per hour, maximum range 0 to 9600 lb. per hour.

BAILEY METERS

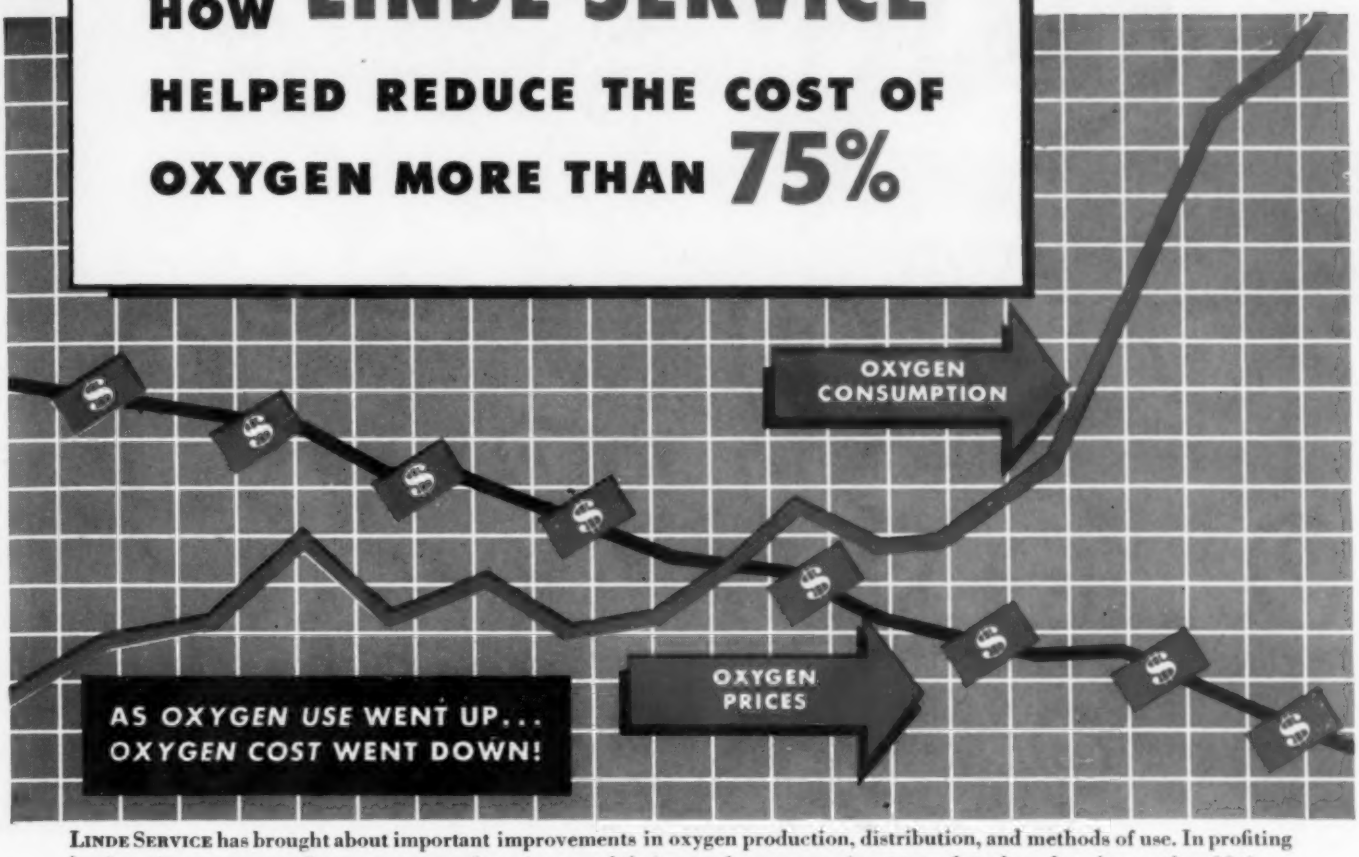
BAILEY METER COMPANY

1047 IVANHOE ROAD
CLEVELAND 10, OHIO

Process Controls

TEMPERATURE · FLOW
PRESSURE · LEVEL
GAS ANALYSIS · RATIO

HOW LINDE SERVICE* HELPED REDUCE THE COST OF OXYGEN MORE THAN 75%



LINDE SERVICE has brought about important improvements in oxygen production, distribution, and methods of use. In profiting by these improvements, LINDE customers have increased their use of oxygen per ingot-ton of steel produced more than 12 times in 25 years. This increased volume of usage in turn enabled LINDE to reduce the cost of oxygen more than 75% in that time.

With LINDE Oxygen you get *all* these important advantages—

- **DEPENDABILITY OF SUPPLY** —— No oxygen shortage due to failure of a single plant. Many strategically located plants to meet every demand.
- **FLEXIBILITY OF SUPPLY** —— No fixed capacities. You get what you need when you need it . . . and pay only for what you use.
- **LOW UTILIZATION COST** —— No capital investment . . . no costly maintenance.

*PLUS . . .** LINDE SERVICE—

The unique combination of research, engineering, and over 40 years of accumulated know-how that is helping LINDE customers save money and improve production in their uses of oxygen and oxy-acetylene processes.

If your company uses oxygen, LINDE SERVICE *can mean dollar savings to you. Let us tell you more about it.*

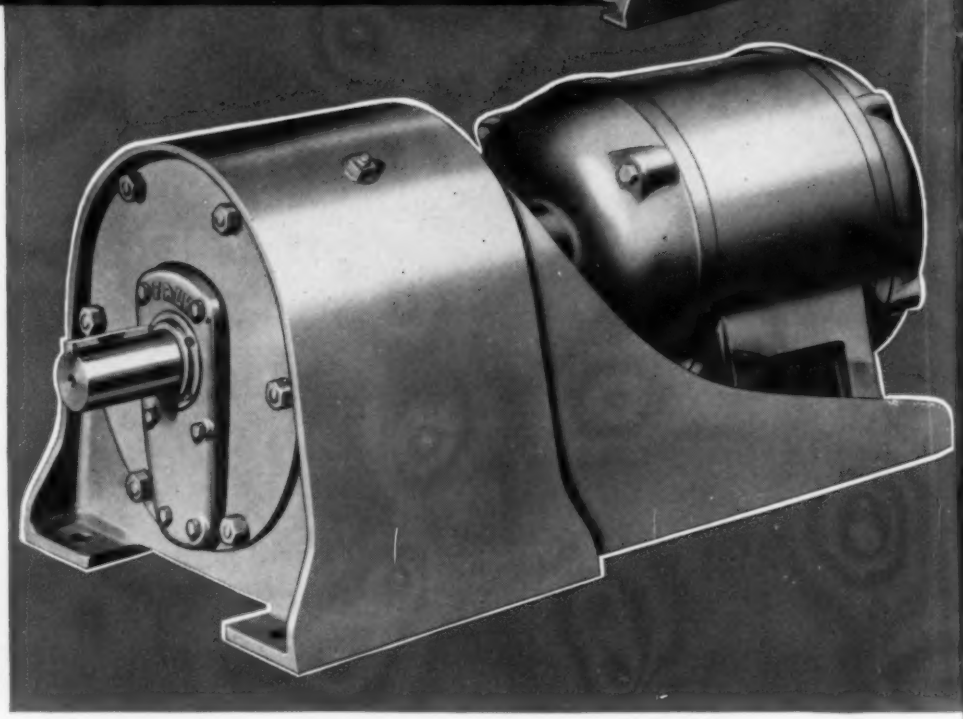
LINDE AIR PRODUCTS COMPANY
A Division of UNION CARBIDE AND CARBON CORPORATION
30 East 42nd Street UCC New York 17, N. Y.
Offices in Principal Cities
In Canada: Dominion Oxygen Company, Limited, Toronto

Linde Trade-Mark

With the All-Motor Type,

ALL-STEEL FALK Motoreducer

you can interchange motors in minutes... *on the job!*

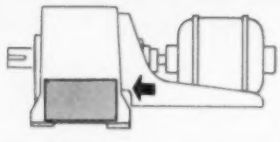


Fast, easy maintenance gives savings in time and money

With the *all-steel,* All-Motor type FALK Motoreducer . . . the only complete and compact motorized reducer with a separately mounted, resilient Steelflex coupling-connected motor . . . you can replace or interchange motors, *or even parts,* in minutes—*on the job,* without long and costly "down time"! Ratios can be changed (within capacity) without motor modification.

Any make, speed, or type of standard foot-mounted motor within the unit's AGMA rating is usable *without modification* on this All-Motor type Motoreducer. Motors with variable speed drive arrangement can be used, if desired. No "partial" motor or special shaft is required in event of motor replacement—simply use a complete motor, available for quick delivery from factory or local stocks without expensive delays.

Add to these exclusive maintenance-saving advantages the FALK "In-built" Factors, described at the right, and you have an unbeatable combination of quality, application adaptability, dependability, long-range economy, and dollar-for-dollar value. Write for Bulletin 3104.



Every FALK Motoreducer has these "In-built" Factors—

Positive Lubrication. Large sump capacity . . . oil-tight construction assures clean lubricant . . . direct dip of revolving elements provides positive lubrication at all speeds.

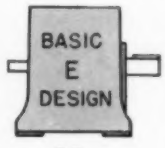
Wide Speed Range. Selective ratio combinations provide output speeds from 1.5 rpm to 1430 rpm with stock gears.

Streamlined inside and outside. Smooth, clean surfaces; machine welded construction conforms to NEMA motor frames.

Sealed Housings. Dual closures and one-way vents keep oil *in,* dust and moisture *out.* Units are splash-proof, leakproof, dustproof.

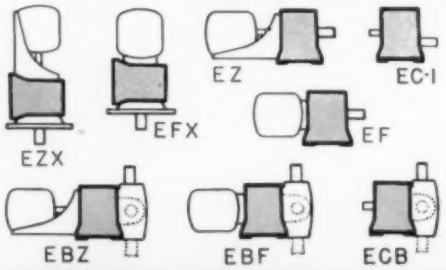
Precision Gearing. Heat treated alloy steel, precision cut and shaved helical gearing throughout . . . quiet-operating crown shaved pinions . . . taper bored gears for easy ratio changes.

All-steel Housings. Unbreakable, strong, rigid. Generous overhung load capacities provided by wide bearing spans, large shafts and bearings.



EC

The basic E design permits maximum use of standardized parts . . . closer control over materials, processing, inspection and assembly . . . resulting in faster delivery from interchangeable stocked assemblies.



FALK ... a good name in industry

THE FALK CORPORATION · 3001 W. Canal St. · Milwaukee 8, Wis.

WRITE FOR BULLETIN 3104

for heat treating bars and tubes

ihp *

SAVES SPACE

Heating bars in a furnace one-third shorter than the length of the bar itself is typical of Selas *Improved Heat Processing.* One company using a 14-foot high-speed radiant, gas-fired furnace doubled its previous output rate in tons per hour of 22-foot bars.

Selas **ihp*** is in use for bars and tubes of stainless, carbon, or alloy steel and non-ferrous metals . . . for hardening, drawing, normalizing and annealing. Treating metals at mill production speeds, *Improved Heat Processing* methods save furnace and storage space, plus many dollars in handling costs.

Every bar is given the same uniform treatment, resulting in consistent metallurgical results not only from end to end of any one bar, but also from bar to bar.

Numerous magazine articles attest to the efficiency of Selas methods. Ask for printed material describing results obtained by companies with problems similar to yours.

Improved Heat Processing

SELAS

CORPORATION OF AMERICA

PHILADELPHIA 34, PENNSYLVANIA

Heat Processing Engineers for Industry — Development • Design • Manufacture

INSIDE AN EXIDE-IRONCLAD

Inside . . . where it counts most . . . EXIDE-IRONCLAD is entirely different than any other battery. It's made that way by EXIDE'S exclusive IRONCLAD slotted-tube construction . . . a principle that provides direct operating-hour savings for you.

OF ALL BATTERIES, ONLY EXIDE-IRONCLADS HAVE POWER TUBE POSITIVES

The positive plate is different . . . unique . . . exclusive. It is the most effective retainer of active material yet demonstrated in heavy duty service. Slotted tubes contain the active material. So fine are the slots that, while permitting easy access of electrolyte, they retard the active material from washing out, hold it during repeated cycles of charge-discharge, and the vibration of rough use.

Today's battery-powered equipment is being used harder than ever before. Unless the batteries have internal shock protection they tend to deteriorate under hard usage—both electrical and mechanical. Only Exide-Ironclad has the plus-protection of the tubular positive that can withstand today's more exacting and rigorous heavy-duty battery services.

Your EXIDE sales engineer will give you the factual inside story. See for yourself why *only* an EXIDE-IRONCLAD gives maximum day-after-day service under the most difficult operating conditions . . . *with a minimum of maintenance expense.*

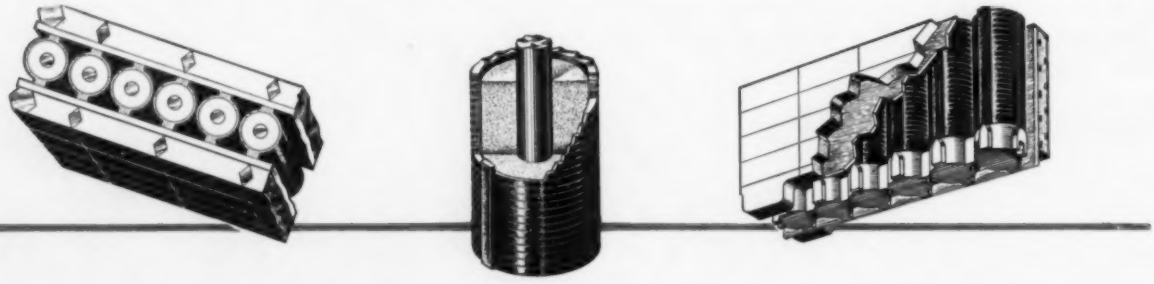
THE ELECTRIC STORAGE BATTERY CO.
Phi'adelphia 2
Exide Batteries of Canada, Limited, Toronto

1888 . . . DEPENDABLE BATTERIES FOR 65 YEARS . . . 1953

Cross section shows relation of positive plate to separators and negative plate. Note the much greater exposure of active material to electrolyte as compared with that of the usual flat positive plate. This greater exposure makes possible the high power ability and uniform-voltage characteristics of the Exide-Ironclad. The negative plates have been made extra heavy to balance the increased capacity of the power tube positives.

Running through center of each tube is an alloy core which is cast with the heavy top cross bar. These form the sturdy, non-buckling grid. Both core and top bar are made of Exide's new corrosion-resistant Silvium, an alloy of silver, lead and other components, which adds greatly to plate's long life.

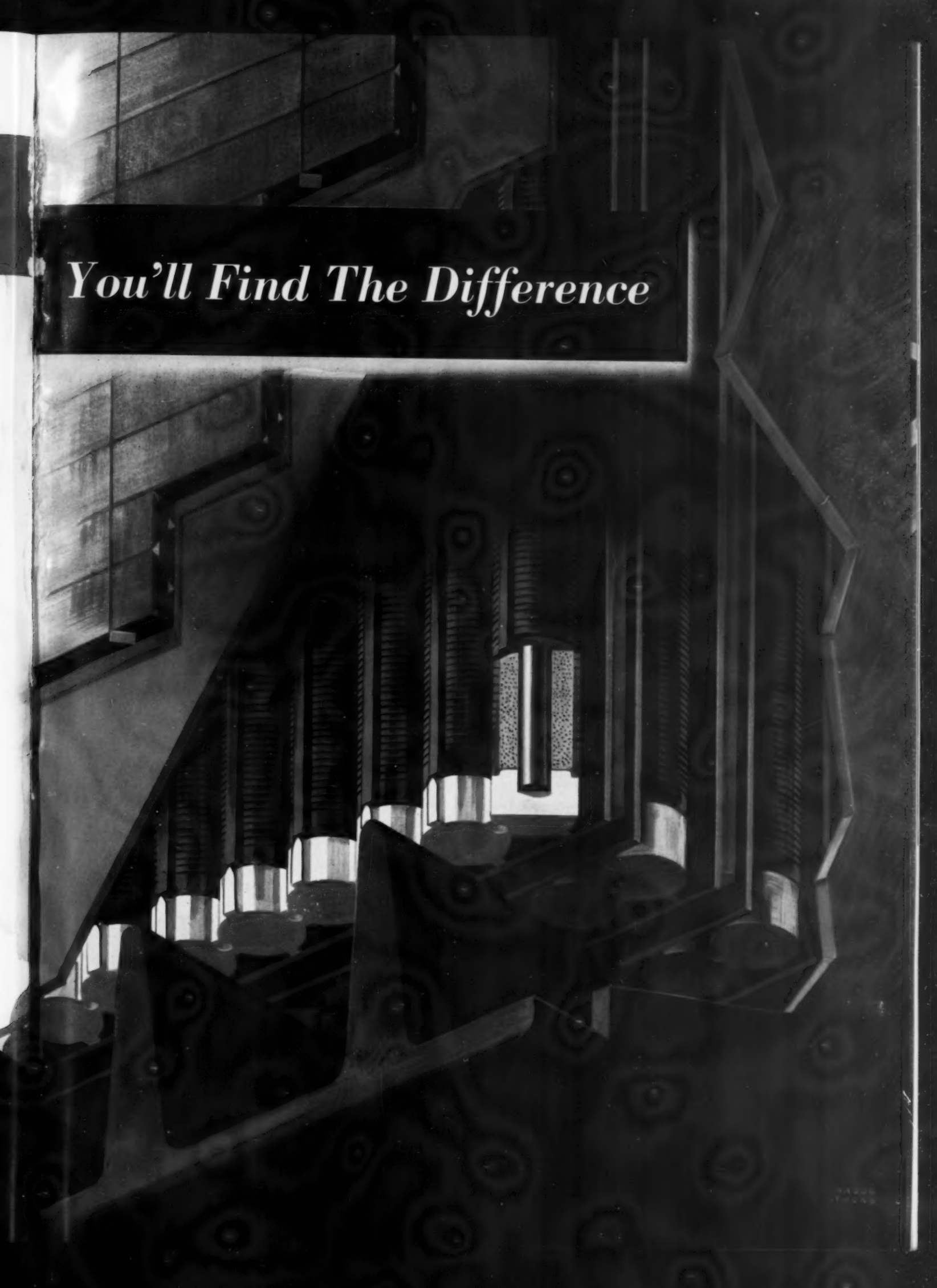
New polyethylene insulating tube sealer of acid-proof, non-corroding plastic fits snugly into bottom of slotted tubes and further reduces loss of active material. Thus more active material remains available, and the high battery capacity is maintained for a longer working life.



Exide-Ironclad

YOUR BEST POWER BUY . . . AT ANY PRICE

"Exide-Ironclad" and "Silvium" *Reg. T.M. U.S. Pat. Off.*


You'll Find The Difference

Simplicity a MUST?

. . . use the oil seal that's designed to save space!

Only 2 simple parts:

The Johns-Manville Clipper Seal consists of only two parts—a one-piece concentrically moulded body and a specially designed garter spring, factory assembled into a single, compact unit. Available in both split and endless types.

THIS EXPLODED VIEW of the revolutionary, new Sier-Bath Gear Coupling shows how Clipper Seals helped one enterprising manufacturer achieve simplicity and compactness in the design of his product.

The result is a thoroughly streamlined gear coupling—comprised of a few simple parts—that is so simple that it can be taken apart—and reassembled—in a few minutes.

Clipper Seal's simple design provided important space-saving advantages that helped make this possible. Seals of a narrow flange section were used to permit making the oil seal cavities of minimum depth. Composed of a rigid heel and a flexible lip moulded as a single unit, each seal does an efficient job of retaining oil and excluding dirt, moisture and corrosive fumes—and does this job in a minimum of space.

If you are looking for an oil seal that will help streamline your product, it will pay you to investigate Clipper Seal's many advantages. They are available in various lip designs to provide a choice of bearing surfaces, in sizes to fit shaft diameters from ⅜" up to 66" and for temperatures up to 450 F. Just write Johns-Manville, Box 60, New York 16, N. Y. Ask for brochure PK-46A.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville CLIPPER SEALS

how to provide
PROTECTION · *PLUS*

for enclosed
gear drives . . .

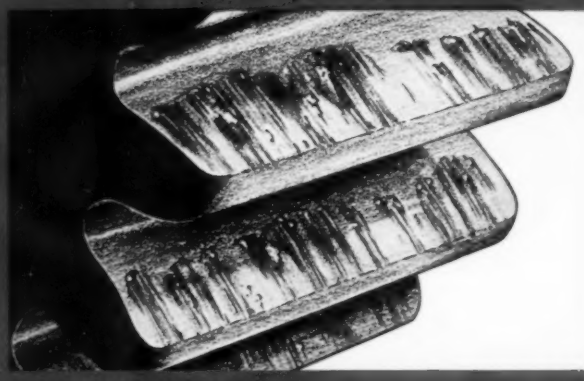
SWITCH TO GULF E.P. LUBRICANTS

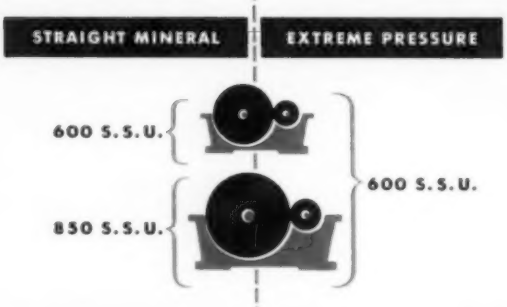
. . . and save maintenance dollars!

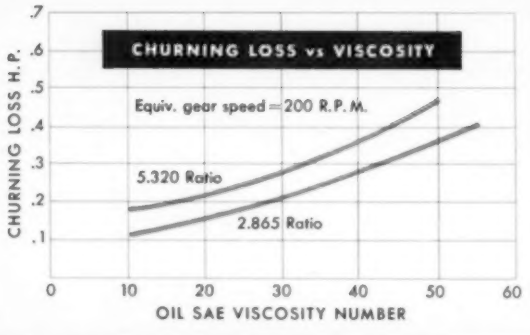
Gulf E. P. Lubricants combine all the properties that count in an extreme pressure lubricant: high film strength, excellent rust preventive properties, good water-separating characteristics, good stability, and they are noncorrosive, nonfoaming. Their use insures longer gear and bearing life and lower maintenance costs for gear drives under a wide range of operating conditions.

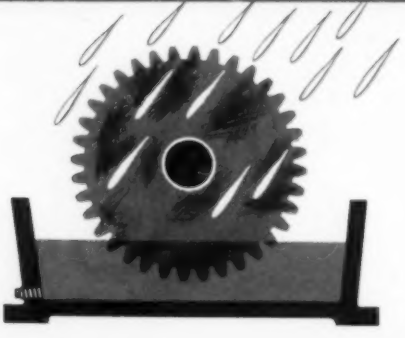
Gulf E. P. Lubricants are available in the proper viscosity for every gear requirement ranging from 55 to 1000 SUV at 210 deg. F. For specific recommendations for your equipment, call in a Gulf Sales Engineer today. Write, wire, or phone your nearest Gulf office or send the coupon on the last page.

GULF INDUSTRIAL LUBRICATION









Practical advantages of Gulf E. P. Lubricants:

More effective protection against tooth scoring and welding

Gulf E. P. Lubricants have proven ability to protect gear teeth against damage by scoring and welding. They are specially compounded to provide extra film strength and to prevent metal-to-metal contact under most conditions of overload and shock load. That's why you can usually avoid tooth damage like that shown at the left when you use Gulf E. P. Lubricants. And that's why they provide an extra margin of protection when production demands approach or exceed the rated capacity of the equipment.

Fewer lubricant grades needed—lubricant storage and handling simplified

Because Gulf E. P. Lubricants have superior film strength, it is often feasible to use a lower viscosity grade than would be possible with a straight mineral oil. This is a practical advantage for plants operating several different types of gear drives. If, as pictured at the left, two straight mineral oils of different viscosity are specified, one grade of Gulf E. P. Lubricant may well do the job of both. Thus lubricant storage and handling is simplified, and there is less chance for confusion in the oil house.

Reduced power loss caused by churning in splash-lubricated units—lower power costs

There is another advantage in using a lower viscosity oil in splash-lubricated units where power loss due to churning is appreciable. Since this loss is almost directly related to oil viscosity, the use of lighter Gulf E. P. Lubricants often means reduced heat generation and lower power costs.

The chart at the left shows the effect of viscosity on the churning loss in horsepower of a typical gear unit.

Excellent protection against rust

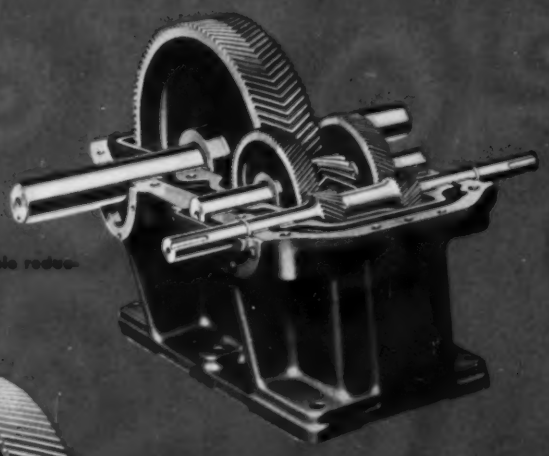
The ability to protect polished gear teeth and antifriction bearings against rust is an important property of a gear lubricant, and is essential in a lubricant for units which are occasionally idle.

Gulf E. P. Lubricants have highly effective rust preventive properties—insure against excessive wear and enlarged tolerances which might result from the presence of abrasive rust particles.

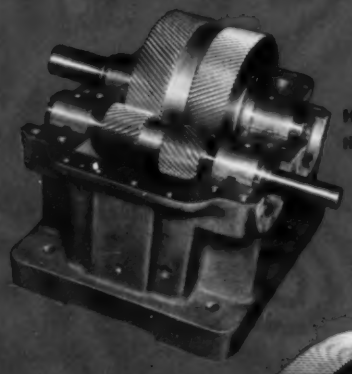
other advantages {

- **good water-separating characteristics**
- **non-corrosive**
- **non-foaming**
- **stable for this type of lubricant**

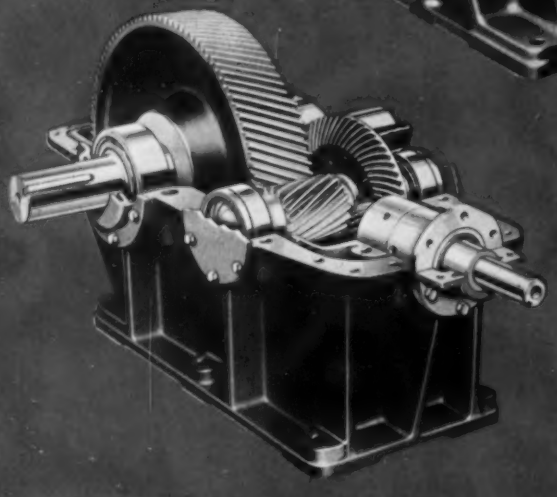
make Gulf E. P. Lubricants ideal for:



Parallel shaft double reduction unit (Falk)



High speed, single reduction unit (Westinghouse)



Double reduction, right angle drive (Falk)

Single reduction unit (Westinghouse)

GULF OIL CORPORATION • GULF REFINING COMPANY
1822 Gulf Building, Pittsburgh 30, Pa.

Gentlemen:

I would like further information on Gulf E.P. Lubricants:

- ☐ Please have a Gulf Sales Engineer call.
- ☐ Please send me a copy of your pamphlet "Gulf E.P. Lubricants for Reduction Gear Drives."
- ☐ Please arrange to show a group in our plant the new Gulf Color Slide Film, "Gears and Their Lubrication," Part I.

Name_____

Company_____

Title_____

Address_____

GULF INDUSTRIAL LUBRICATION

UNION

DOUBLE-LIFE HEAD CHARGING BOXES

Open Hearth Champions!

Heavy loads, sudden changes of temperature, torsional twists and shock are all in the day's work for "Union" Peels.

Universal Couplings and Spindles as cast by "Union" actually cost less... last longer... are easier to machine... require less down-time for replacement. Furnished in the rough or completely machined.

THERE'S NO DOUBT ABOUT IT. In every steel plant where UNIVAN boxes work alongside ordinary ones, they outlast them by *months!* This economical long life is due to the exclusive Double-Life Head plus a better casting design. When measured by tonnage handled and length of service you'll find "Union" the best buy *by far*... write for facts and figures.

BLAW-KNOX COMPANY
UNION STEEL CASTINGS DIVISION
PITTSBURGH 22
PENNSYLVANIA

BLAW-KNOX

JOY Plugs and Receptacles . . .

Industry's favorite electrical connectors

The most convincing sellers of JOY plugs and receptacles for Industrial applications are JOY plugs and receptacles themselves. Records prove that the initial installation in a Steel Mill, Scrap yard or Foundry invariably leads to widespread usage on many different types of mobile and stationary equipment.

Molded as one-piece Neoprene units, JOY connectors can't crack or smash out of shape when dropped — won't become mushy when smeared with grease or oil — and are absolutely moisture tight. Cork-like action of their water-seal also prevents metallic dust from accumulating around contacts.

Why accept less when the best actually costs less in the long run? For proof give us a brief description of your current needs. We'll welcome the opportunity of recommending the right JOY connectors to solve them . . . without obligation.

BULLETIN B41

THIS NEW BULLETIN IS YOURS . . . FOR THE ASKING

Our supply on this attractive new three color bulletin is adequate . . . *we had an extra large quantity printed* . . . however why not ask for your copy before it slips your mind? By doing so you'll be sure to have up-to-date reference material on JOY'S products at hand the next time you need good electrical connectors.

Consult a Joy Engineer

M.E. 153.5

JOY MANUFACTURING COMPANY

HENRY W. OLIVER BUILDING, PITTSBURGH 22, PENNSYLVANIA

IN CANADA: JOY MANUFACTURING COMPANY (CANADA) LTD., GALT, ONTARIO

FARRELL-CHEEK

ELEVATING and CONVEYING

F 85 ALLOY CAST STEEL BUCKETS

Finest Name in Cast Steel!

FARRELL-CHEEK STEEL CO.

HIGHEST QUALITY ELECTRIC FURNACE CARBON AND ALLOY STEEL CASTINGS

FARRELL'S CARBON STEEL CASTINGS

F-C HARD EDGE STEEL CASTINGS

F85 STEEL CASTINGS

RAILROAD CASTINGS
Locomotive and Car R. R. Specialty Castings

ELEVATOR, CONVEYOR PARTS
Sprockets, Traction Wheels, Chains, Buckets, Rollers, Idlers, Bushings.

GEARS AND PINIONS
"True Tooth" Gears and Pinions, Sheaves and Wheels.

CRANE WHEELS
Overhead, Gantry, Monorail, Ingot Car, Charging Machine.

STOKER PARTS
Feed Screws, Furnace Tools, Flanged Pipe, etc.

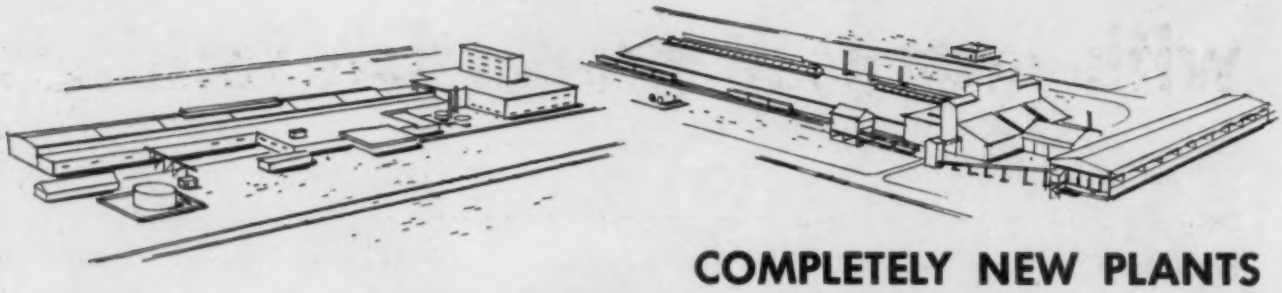
HEAVY HARDWARE
Complete Line Wire Rope Fittings and Cutters, Bar Benders and Cutters.

YOUR INQUIRY WILL PROMPTLY BRING DETAILED INFORMATION PERTAINING TO ANY OF THE ABOVE FARRELL-CHEEK PRODUCTS

SANDUSKY, OHIO

HARBISON-WALKER

the world's largest producer of

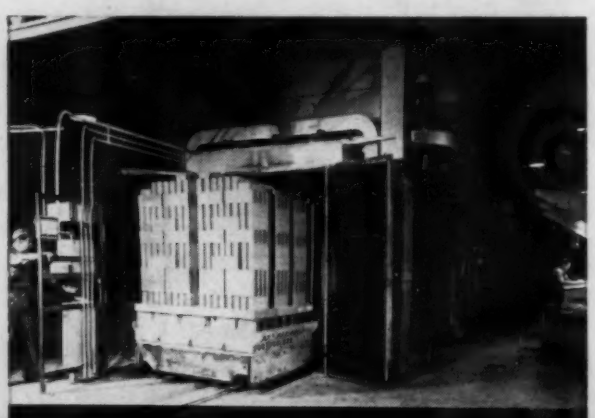


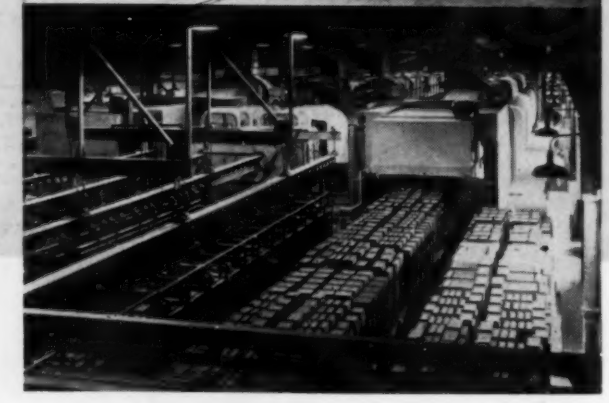
COMPLETELY NEW PLANTS

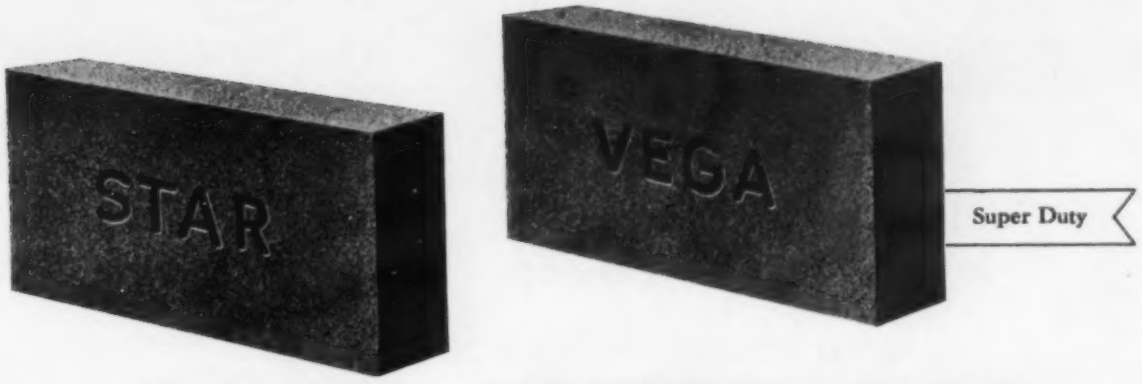
AND EXPANDED FACILITIES IN OTHER PLANTS

ADD TO HARBISON-WALKER'S SILICA BRICK CAPACITY

Silica refractories are made in Harbison-Walker plants in Pennsylvania, Ohio, Alabama, Indiana, Texas and California. The illustrations show the modern tunnel kilns in which STAR and VEGA are fired. Throughout all mining, processing, forming, drying and firing operations, modern methods and equipment are used to insure the uniformity and high quality of Harbison-Walker silica refractories.







SILICA BRICK

meets the greater demand with increased production facilities!

Over the years, the use of Harbison-Walker STAR and VEGA brands has steadily increased. For more than half a century, STAR has been the standard of quality for silica refractories. Continued research, developments in every step of the manufacturing procedures and close laboratory control, all contribute to the uniform high quality of STAR and VEGA.

VEGA brand, the original super-duty silica brick, first introduced over a decade ago was developed to meet the need for a silica refractory which provides the margin of refractoriness for the operation of furnaces at higher temperatures. Used under normal operating conditions, VEGA gives longer life and reduces maintenance costs.

Harbison-Walker continues its leadership of the progress in the production of silica refractories. To meet the greater demand for STAR and VEGA, Harbison-Walker has recently completed an extensive expansion program which has greatly added to the capacity for producing these refractories.

HARBISON-WALKER REFRACTORIES COMPANY
AND SUBSIDIARIES
World's Largest Producer of Refractories
General Offices: Pittsburgh 22, Pennsylvania

● BLAST FURNACES
● OPEN HEARTH FURNACES
● CONTINUOUS REHEATING FURNACES
● SOAKING PITS
● ANNEALING FURNACES
● GALVANIZING FURNACES
● ORDNANCE FURNACES
Over 46 years of experience and demonstrated engineering skill in the design, construction and erection of all types of furnaces— from the blast furnace to the smallest heat treating units.
STANDARD BOILER
FOUR AFFILIATED COMPANIES TO SERVE YOU BETTER ...any time, anywhere!
F·E·I·
B
■ STANDARD BOILER & PLATE IRON CO.
■ NILES CONSTRUCTION COMPANY
● FURNACE ENGINEERS, INC.
● BRASSERT CORPORATION
C. A. Brassert, President
General Offices:
UNION BANK BUILDING,
Pittsburgh 22, Pa.
PLANTS AT NILES, OHIO

Wagner

Protected Type Motors

solve tough production problems

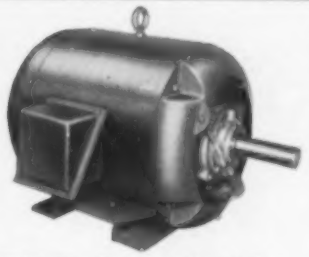
Do you need motors to operate under severe conditions? If you do—you can solve your problem easily with Wagner's complete line of protected type motors.

They are specifically designed for use wherever EXTRA protection is demanded —for bearings or windings . . . against corrosive vapors or abrasive dusts . . . in explosive atmospheres or in exposed outdoor locations.

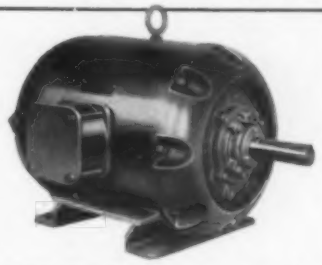
In their specific applications, each of these Wagner Motors assures complete protection of vital parts. Wagner Motors are backed by more than sixty years of motor building experience.

* * *

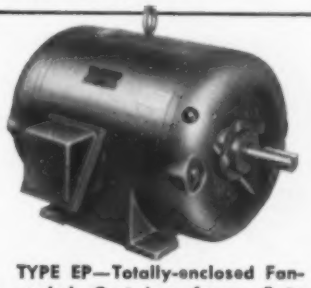
A Wagner engineer will be glad to help you select the correct motor for *your* specific application. Consult the nearest of our 32 branch offices, or write for Bulletin MU-185 for complete information.



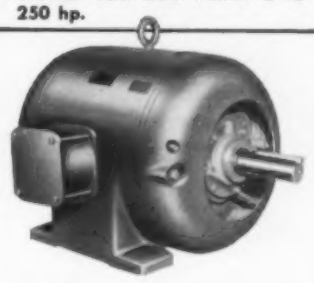
TYPE CP—Totally-enclosed Fan-cooled. Steel frame. 1 to 250 hp.



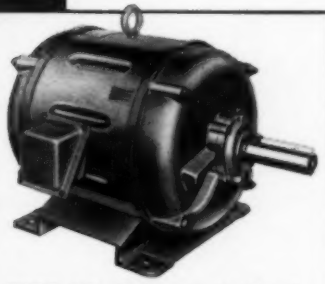
TYPE HP—Explosion-proof. Steel frame. 1 to 250 hp.



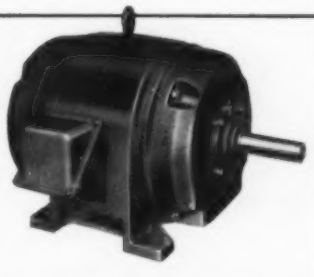
TYPE EP—Totally-enclosed Fan-cooled. Cast iron frame. 2 to 250 hp.



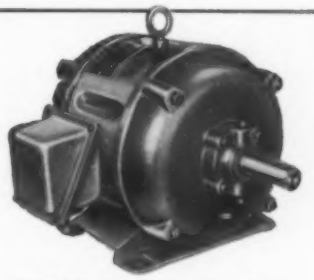
TYPE JP—Explosion-proof. Cast iron frame. 2 to 250 hp.



TYPE RP—Drip-proof. Steel frame. ⅛ to 400 hp.



TYPE XP—Splash-proof. Cast iron frame. ¾ to 200 hp.



TYPE TP—Totally-enclosed, non-ventilated. ¼ to 15 hp.

Wagner Electric Corporation
EST. 1891

WAGNER ELECTRIC CORPORATION
6483 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES
AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

BRANCHES IN 32 PRINCIPAL CITIES

M53-10

BLISS MILLS PACE REVERE

This 6" and 28" x 30" mill features a coolant system engineered by Bliss to control the roll crown. The system is unusually complex, having a large number of coolant jets, each affording individual control for optimum range of selection.

IN ILLINOIS...

Revere Copper and Brass Incorporated is not one to rest on the laurels of its 150-plus years of experience and accomplishments. Revere is constantly expanding and improving its facilities.

That's why Revere's recent effort to get added rolling efficiency and capacity resulted in installation of four new Bliss mills in three different manufacturing divisions: two mills in Rome, N. Y., and one each in Chicago and Detroit.

All the Bliss units are four-high reversing mills for reducing copper and brass. Each is a wet mill having a coolant system that permits exact control of the roll crown, in addition to cooling strip. And each is equipped with expanding mandrel reels—used both for tension and pay-off—and coil buggies for each reel.

Back-up rolls are driven instead of work rolls. Since mill speed depends on peripheral speed of the back-up roll, work rolls of varying diameters (5¾" to 8") can be used without affecting operating speed of the mill.

Revere uses the mills to reduce hard copper from 0.030" to 0.015" and from 0.025" to 0.010". Both copper and brass are rolled to gages in the 25-inch width, as light as 0.004". Brass is reduced 50 to 60% between anneals.

You, too, can look to Bliss to fill your major rolling mill needs. Whether it's a hot mill or a cold mill...brass, copper, steel or aluminum...breakdown, rundown or finishing... Bliss can build it. See the complete line in our illustrated Bulletin 40—yours for the asking.

E. W. BLISS COMPANY

GENERAL OFFICE: CANTON, OHIO

ROLLING MILL DIVISION: SALEM, OHIO

E. W. Bliss (England) Ltd., Derby, England

E. W. Bliss Company (Paris), St. Ouen sur Seine, France

U. S. plants at Canton, Salem, Toledo, Ohio; and Hastings, Michigan

Branch offices in Chicago, Cleveland, Dayton, Detroit, Indianapolis, New Haven, New York, Philadelphia, Rochester, Toledo; and Toronto, Canada. West Coast Representatives: Moore Machinery Company, Los Angeles and San Francisco; Star Machinery Company, Seattle. Other dealers in U. S. cities and throughout the world.

PLANT EXPANSION

Operator's side—showing plainly the vertical-type belt wrapper over tension reel, control cabinets, and reversing-direction coil ramp.

MICHIGAN...NEW YORK

Remember:
for Presses, ROLLING MILLS
...and Special Machinery...

It's Bliss

Cleveland Cranes
FOR
STEEL MILL SERVICE
CLEVELAND
CLEVELAND CRANES
MODERN ALL-WELDED STEEL MILL CRANES
5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

STEEL producers in general are looking for a let-up in steel demand. Opinions mention an "average close to 90 per cent in the fourth quarter," a "drop to 80 per cent by December," and a "dip to 85 per cent in October or November and along that level through 1954." Some companies expect to operate above the national average for reasons of reputation, geography, etc.

The companies are apparently not worried about the profit outlook, but rather seem to welcome the respite as a chance for the industry to stabilize and do some much-needed rebuilding.

▲

NOW that vacation season is over and bare limbs will be seen only on trees, a lot of people have discovered that it's a long time paying for a short time playing. The Wall Street Journal says a vacation is a success if we manage to change the color of circles under our eyes from black to tan.

▲

ACCORDING to the American Iron and Steel Institute, electric furnace production of steel during the first six months of 1953 reached a record tonnage rate of more than 4,200,000 net tons of steel and a record proportion — 7.3 per cent — of all steel produced. Of further interest is the fact that about 52 per cent of the electric furnace output was carbon steel.

Electric furnace capacity now constitutes 8.7 per cent of the country's total steelmaking capacity. They are now used by 60 companies, nearly three-quarters of all ingot makers.

In keeping with the growing interest in electric furnaces, the AISE convention program, shown elsewhere in this issue, includes two sessions dealing with the economics and the electrical phase of these units.

▲

A new government-owned steel plant with an annual capacity of 500,000 tons will be built in India. The German firms of Krupp and Demag will help in financing and constructing it.

▲

IT seems odd, but as various metals have been taken off allocation, the supply has become relatively free, and in many cases prices have dropped.

A correspondent gives us a new definition: Middle age is the time of life when women won't admit their age and men won't act theirs.

And we might add that old age is when a man can remember buying a good lunch for 30 cents, or doing without things when they cost too much.

▲

STATISTICS from employee insurance records of United States Steel Corp. show that three times as many lost-time accidents occur to the company workers during their leisure hours as happen on the job.

▲

AN unusual method of enlarging a blast furnace was used at John Lysaght Works, Scunthorpe, England. The furnace shell was cut off just above the mantle, raised six feet by jacks, and supported by added shell plates rising from the mantle. The working volume of the furnace was increased 12 per cent.

▲

DOCTOR bills are usually the last paid. The finance company can take back the car and TV set but the doctor can't put Junior's tonsils back.

▲

MORE new records for the industry were announced by the American Iron and Steel Institute. In June, total employment in the industry reached 690,200 and the average hourly rate of wage earners rose to $2.263. Wage earners worked an average of 39.9 hours per week, and the total payroll is estimated at $282,172,000.

▲

THEY tell us that federal spending cannot be cut without hurting the defense program — but what about the $21,700,000,000 increase in non-military spending in the five years since 1948?

▲

GUNPOWDER is a black substance which nations use in determining boundaries but it isn't nearly as effective as your neighbor's lawnmower when he cuts his lawn.

▲

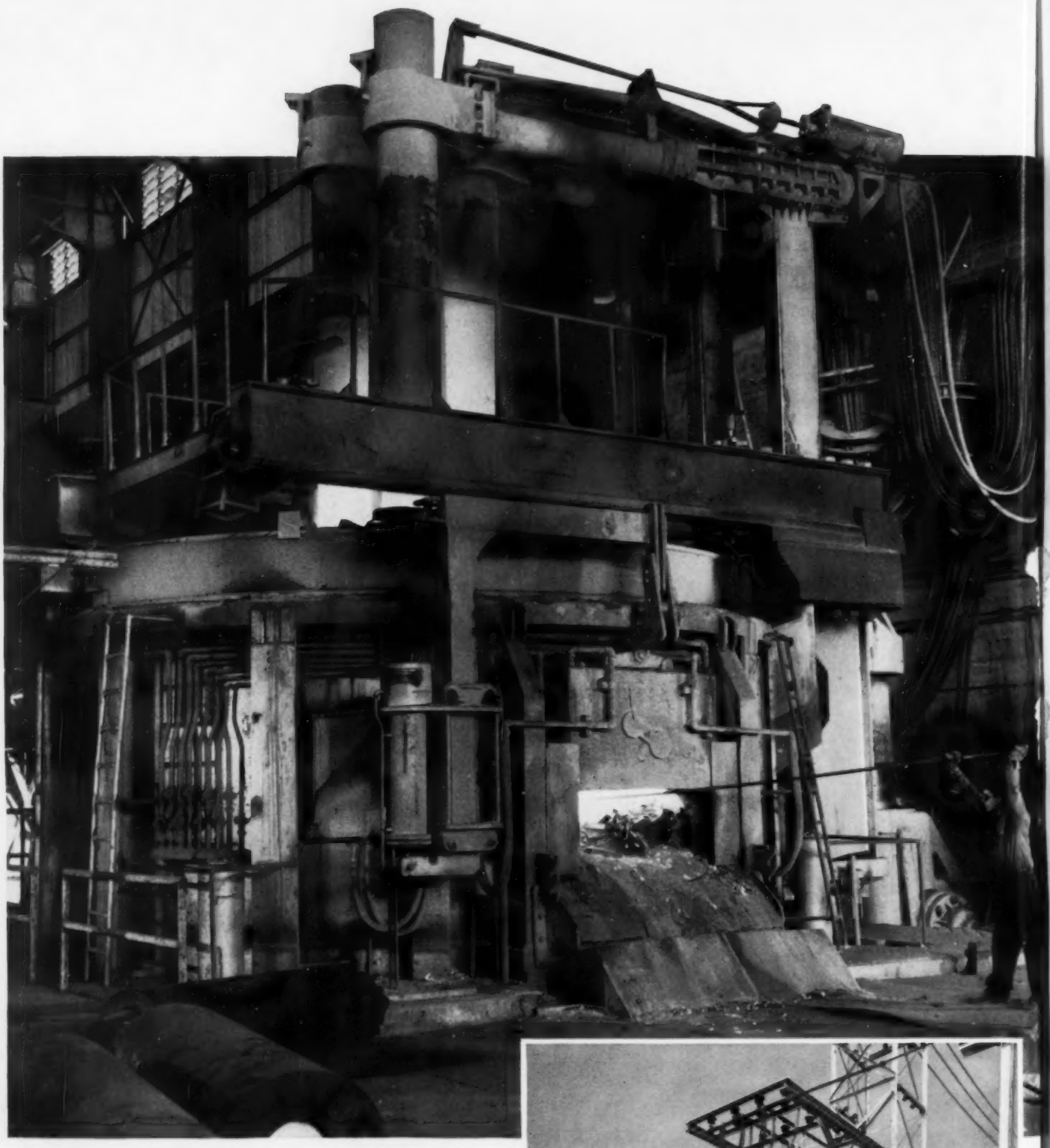
THE week of October 4-10 is Fire Prevention Week, and we should stop to consider that every day there are 920 home fires, 78 store fires, 100 factory fires, 8 church fires, 9 school fires, 4 hospital fires — and 33 deaths by fire. In 1952 the combined United States and Canadian fire loss totaled nearly one billion dollars.

▲

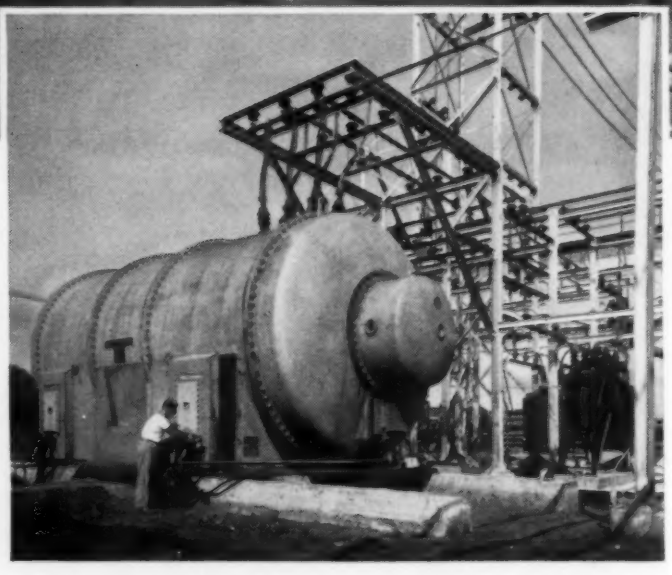
TEN cents used to buy quite a number of things, but dimes have changed. A dime isn't completely worthless, however; it still makes a tolerable emergency screw driver.

▲

IN the month of July, there were 63,120,000 jobholders in the United States. About 15,000,000 workers are covered by union contracts.



This Northwestern Steel & Wire Company furnace, at Sterling, Illinois, is the largest arc furnace in service in the world. The first of three such furnaces being installed here, it's expertly controlled by Westinghouse Rototrol.



Northwestern's new 60/70,000 kva synchronous condenser, built by Westinghouse, has helped increase the power system's stability and has eliminated light flicker.

Westinghouse package boosts furnace output, cuts power costs

Largest arc furnace in the world . . . or the smallest . . . no matter what size you're planning, a Westinghouse power-package, backed up by Westinghouse engineering help, will make your furnace production figures glow.

Engineering help

Westinghouse engineers will help you plan a complete, one-package electrical installation, including a power supply setup that can handle tremendous loads. Look, for example, at the new Westinghouse synchronous condenser, pictured at the lower left. Installed at Northwestern Steel and Wire Company for the world's largest arc furnace, this unit absorbs peak power requirements and minimizes disturbances to the electrical system.

Two electrical brains

Westinghouse Rototrol® maintains desired power input by quickly, accurately and automatically adjusting the electrode position, according to changing furnace demands. Optimelt®, another Westinghouse development, can provide even more precise control by automatically determining the best kw input.

First with the finest

To withstand the power surge when the furnace electrode touches the charge, Westinghouse supplies a shell-form transformer . . . far stronger than other types of construction. Also, Westinghouse has developed new hard-working air-blast circuit breakers. These provide 500 kva interrupting capacity for furnaces up to 1200-2000 amperes. Imaginative engineering like this helps explain why more Westinghouse furnace equipment is in use than all other makes combined.

Booklet of ideas

A free 20-page booklet, *Westinghouse Equipment for Arc Furnaces,* can spark ideas for your operation. Here's convincing evidence . . . facts, installation photos, technical data . . . to show that it's wise, when your next project comes up, to call Westinghouse before planning begins. Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pennsylvania. J-94984

YOU CAN BE SURE...IF IT'S

Westinghouse

Westinghouse Electric Corporation
P. O. Box 868
Pittsburgh 30, Pennsylvania

Please send my free copy of B-4695, *Westinghouse Equipment for Arc Furnaces.*

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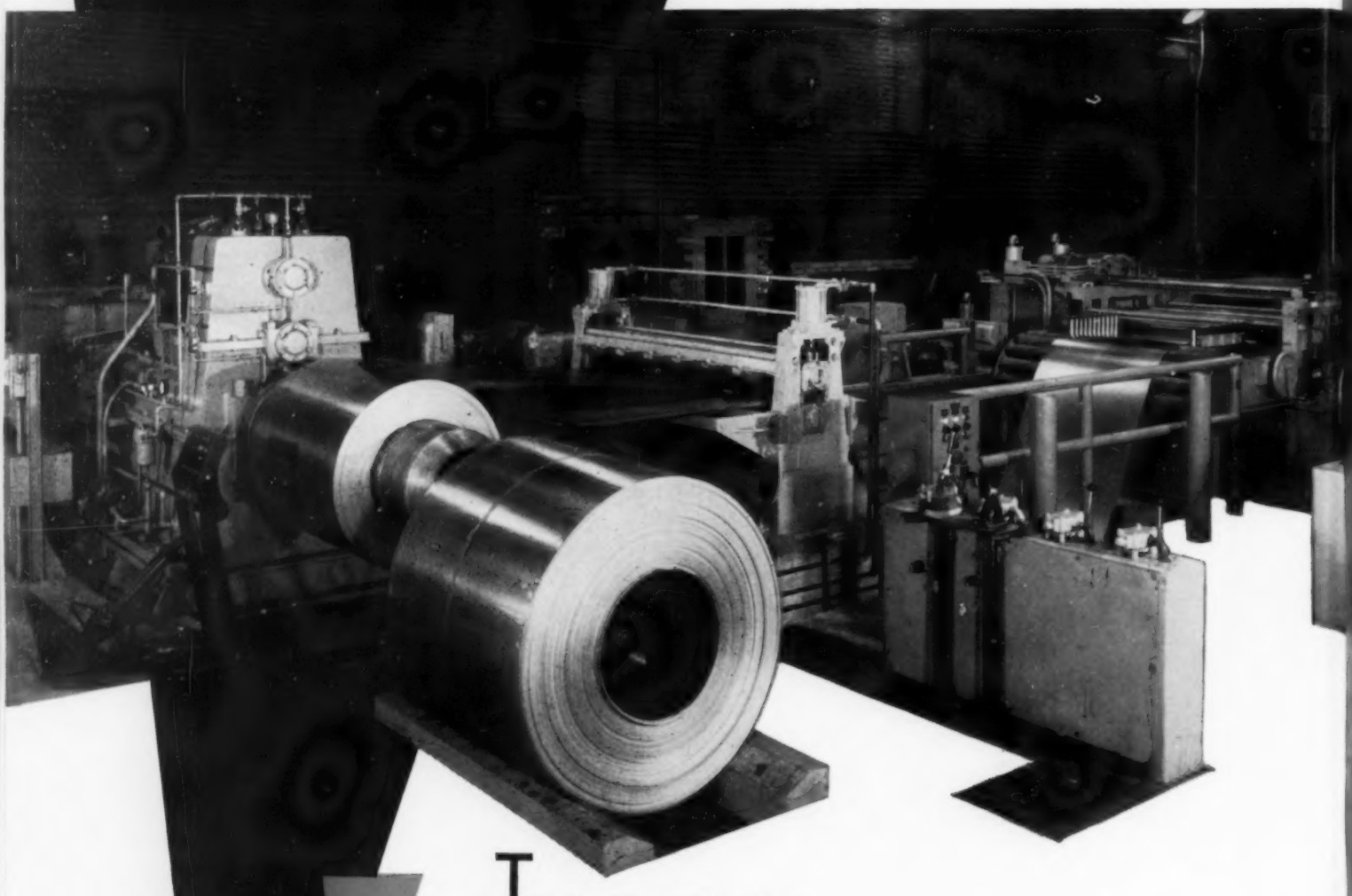

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WHEN YOU MELT... *Lectromelt*

A MAINTENANCE MATERIAL PROGRAM

By J. E. ANDERSON
Research Engineer
and
J. B. WHITLOCK
General Maintenance Engineer
Armco Steel Corp.
Middletown, Ohio

. . . . material failures may be attributed to four causes: improper design of section, misapplication of material, inferior installation, and abuse of equipment . . . .

▲A study of the general topic of maintenance will soon reveal the fact that the materials used in the building of a piece of functional equipment play a very important part in the continuity of the operation of the equipment. Such a study will likewise reveal the fact that it is always the failure of some material section that creates an equipment delay and that it's repair or replacement results in a maintenance expenditure.

It is this material failure phase of maintenance which we wish to cover, and we have chosen to call this phase of our maintenance program "Failure Research."

FAILURE RESEARCH

Failure research is a phrase we have coined to describe one phase of our maintenance program and it simply involves two things—the asking why a piece of equipment failed and what can be done to prevent a similar failure in the future.

Failure research may lead into a design investigation, material research, or a study of operating practices in order to find the answer to this question "why." Usually the answer can be readily found and immediate corrective steps taken—but some failures have occurred requiring extensive research.

A study of our maintenance costs reveals the fact that sixty cents of each maintenance dollar is spent for materials. So aside from the preventive maintenance value received from failure research, a reduction of material maintenance expenditures may be experienced.

Failure research in our preventive maintenance program must originate with the departmental maintenance supervisor whose department has experienced an equipment delay. He is the man who first asks the question "why" and if the answer is not easily forthcoming, he is the man who channels the investigation through this field of failure research. The first man contacted by the supervisor is the material application man of the division who will be asked to make a complete investigation of the failure and endeavor to find the correct solution for the prevention of the recurrence of such a failure in the future. In making such an investigation, the material application man may solicit the services of the division engineer and/or the division metallurgist. If the investigation is not productive at the division level or if it leads into a field requiring extensive research, the problem is referred to the material engineer of the general maintenance staff. This engineer, together with engineers of the research department and the general engineering department, will do all possible to find a satisfactory solution to the problem.

Many problems have been solved by employing this procedure and many equipment failures have been eliminated. The correct solution to a given problem in failure research is always reported by the material engineer in a written report. This report is then circularized throughout the other divisions of the corporation, thus aiding in the elimination of similar failures in these divisions.

This plan of failure research has been in operation for oven ten years—so today we believe that the questions why and what have become automatic with our maintenance supervisors. Also, as a result of this program, much valuable data have been accumulated

which is proving to be of great every day value to our maintenance crews and supervisors, together with the engineering departments.

Our experience in this field has shown us that maintenance material failures naturally group themselves into four general classifications:

1. Improper design of material sections.
2. Misapplication of material in the original design.
3. Inferior installation.
4. Misuse or abuse of equipment in operation.

The assignment of a classification to a material failure—after the question "why" has been answered—is essential. In fact the assignment of an accurate and impartial classification to a material failure may well be considered to be the keystone of a successful failure

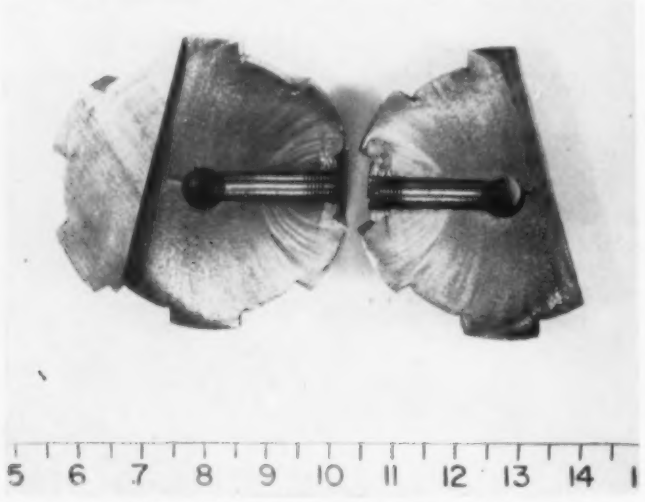


Figure 1 — Failure here occurred because of stress concentration.

research program. The assignment should never be made in a vindictive spirit nor should it ever be made without first carefully weighing all available facts, since the establishment of a favorable reputation for just assignments is essential. It is only through such a favorable reputation that everyone concerned will be ready and willing to cooperate in all of the phases of the failure research program.

In order to illustrate some of the work that has been done in our program, several examples have been

Figure 2 — Service was poor from ingot buggy coupling rings when they were torch cut from slabs.

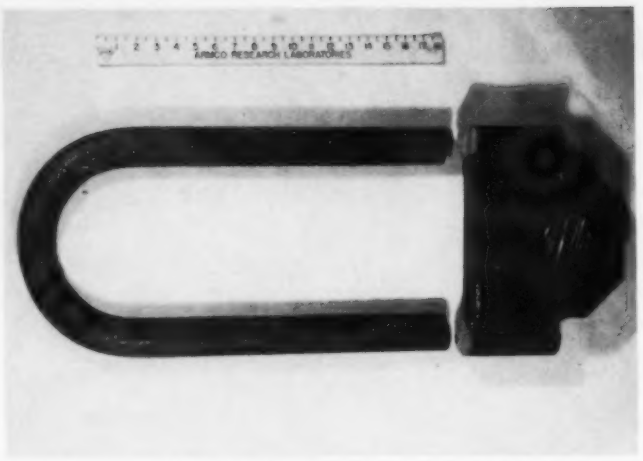


Figure 3 — Welded clevis resulted in a bad failure.

chosen. These examples have been chosen so as to illustrate these four classifications and to portray this part of our program in graphic form.

Figure 1 illustrates a failure which was classified under *Category No. 1, Improper Design of Material Sections.* This is a cross section of a horizontal reversing shaft from a diesel locomotive crane. Fatigue started at the threaded section of a hole for compressed air and very shortly would have resulted in complete fracture, if the crack had not been discovered during a routine inspection. Several similar failures of horizontal reversing shafts were experienced at about the same time. The material used in making the shaft was examined chemically and microscopically, and was found to be a properly heat-treated low alloy shafting steel

Figure 4 — Failure in clevis resulted because no heat treatment was performed after welding operation.

of very good quality. The breakage was reduced immediately by countersinking the threaded hole, a simple change of a design feature. Eventually the splined shaft was completely redesigned to eliminate the threaded hole in the side of the shaft.

Figure 2 illustrates another simple design change which has resulted in the saving of maintenance time and money. Links for ingot buggy couplings were formerly torch cut from slabs. A considerable amount of breakage occurred and was considered a normal maintenance headache. A change in the method of manufacture was recommended by the material engineer. The link pictured here has been pierced and formed in

the forge shop and has smoothly chamfered edges. Breakage has been greatly reduced. Pins for the same couplings were formerly machined. The pin shown here was torch cut from a round bar of good quality shafting steel, and heat-treated after torch-cutting. There are virtually no stresses on the torch cut areas of this pin. The torch cutting method has provided a cheaper and more satisfactory coupling pin than those made in the machine shop.

Figure 5 — This arch bar failed because of insufficient strength in the material.

Figure 3 shows a failure placed in *Category No. 2, Misapplication of Materials in Original Design.* It is a clevis from a dolomite slinger used in an open hearth shop. The clevis was not a replacement part, but was furnished with the slinger. Failure of the clevis occurred while the slinger was in service. Fortunately no one was injured. Notice that the clevis is essentially a rather heavy round bar formed and welded to a slab section.

Figure 6 — Careless use of torch resulted in failure in this flywheel shaft.

Figure 4 shows the fractured surfaces of the clevis. The failure was initiated by fatigue adjacent to the welded areas. No heat-treatment was performed after the welding of the clevis. Although the service life of this equipment was reasonable before failure occurred, safety aspects led to the recommendation of a one-piece forged clevis.

Figure 5 shows another failure attributed to the misapplication of materials in original design. It is the fatigue failure of a diesel engine arch bar. The arch bar was made of an ordinary hot-rolled low-carbon steel. The use of a higher strength material for this part has eliminated recurrence of this type of failure.

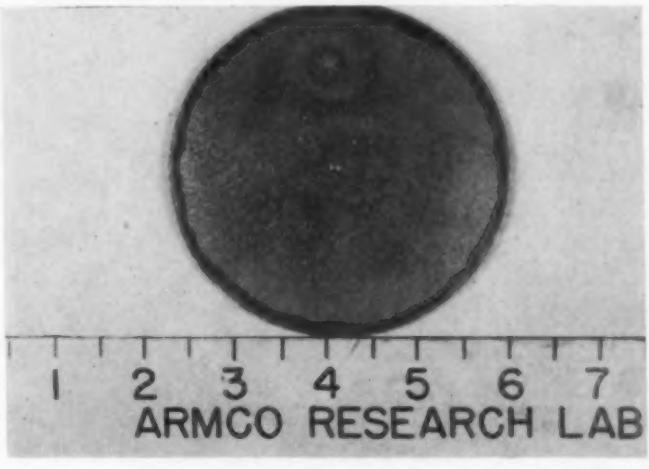
Figure 6 shows a failure attributed to inferior installation of maintenance parts. It is a flywheel shaft from a press brake. In making Rockwell determinations around the circumference of the broken shaft, some spots were found to be much harder than others. A section was cut near the failure and etched. Four places around the shaft were found to have been heated. Upon investigation, a millwright was found to have used a torch in assembling bearings on the shaft. The surface of the low alloy steel became hot enough in four places to be quenched and embrittled by the mass of the shaft itself.

Figure 7 — Failure started near the surface of this armature shaft.

Figure 7 shows the fractured surface of an armature shaft from an open hearth hot-metal crane which failed in service. Failure started at or near the surface. No change in section or keyway was involved.

Figure 8 shows the results of deep-etching a cross-section of the shaft adjacent to the failure. It can be seen that the shaft had become worn in service and had been rebuilt by hand welding. This is a practice which, although useful in many instances, is discouraged for overhead applications where safety is involved.

Figure 8 — Deep-etching showed failure in shaft was due to rebuilding by hand welding.



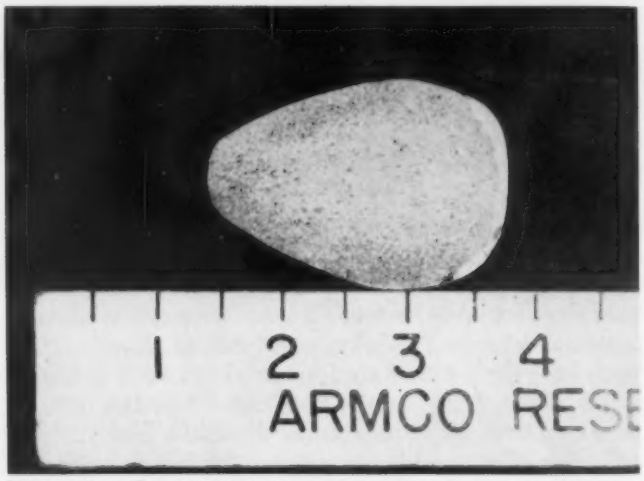


Figure 9 — Rebuilding of tension side of crane hook combined with bad usage resulted in a failure.

Figure 9 shows an etched cross section of a broken crane hook. This item was an ordinary forged hook used in the shipping department of one of our plants. The failure was due in part to poor installation practice and in part to misuse of equipment. The inner face of the hook was found to have been built up by welding, certainly a dangerous practice for the tension side of crane hooks. Second, this failure was one of a series in this department in which, during the use of the crane, the hook sometimes caught under a flange of a loaded railroad car. This type of use seemed to result in broken hooks whether or not they had been built up by welding.

Figure 10 shows a broken shear shaft, one of a series of such failures. The use of the best material available, properly heat-treated, with carefully polished fillets and well made keyways did not stop the failures. It was finally found that the shear had been originally constructed to shear 0.080-in. material 60 in. wide. It had been rebuilt to shear 90-in. stock, and was being used for 120-in. coils. No change in the shaft arrangement had been made. The shaft diameter was thereupon increased from five to five and one-half in. and the service life was extended to normal. This failure was classed under misuse of equipment.

Figure 10 — Overloading resulted in the failure of this shear shaft.

In addition to the failure research program, we have found it necessary to execute a second material program, which we term "Material Betterment." This program deals mainly with the improvement in the life of expendable materials, either through an improvement in material or through a constructive salvaging of the material section. This program is being carried on continuously and very satisfactory progress has been made.

MATERIAL BETTERMENT

The next series of illustrations show a few phases of the material betterment program. Some of the betterment ideas come from the material engineer and the headquarters staff, but many more are available, if they can be uncovered and interpreted, from the individual millwright and his turn foreman.

TABLE I

Typical Paint Specification

General Purpose Zinc Chromate-Iron Oxide Primer for Steel

	Per cent
Pigment: 35 to 40 per cent	
Spanish iron oxide (95 per cent Fe_2O_3)	65-75
C.P. zinc yellow	25-35
Vehicle: 60 to 65 per cent	
Alkyd resin solids	46
Petroleum thinner	52.5
Cobalt naphthenates	1.5
Manufacturers:	
American-Marietta Co. No. 120-Y-2	
Devoe and Raynolds Co. No. ML-977	
Pittsburgh Plate Glass Co. No. 17-6	
E. I. Dupont de Nemours and Co. "Dulux: Zinc Chromate Metal Primer"	
Porter Paint Co. No. 7523	
Sherwin-Williams Co. No. 14A	
Socony Vacuum Oil Co. No. 13-R-43	

Table I shows a page from the paint specifications used by our company. Sometime ago it was realized that the maintenance paint then in use by Armco was essentially the same as had been used twenty years before. Therefore, a committee was established and a survey was made of the paints and painting methods used in all divisions. New paint formulations were drawn up, such as the one shown here, and are now in use at all divisions. It is our belief that the use of the more modern paints will result in longer life per application and the eventual saving of considerable maintenance money in man-hours consumed in painting.

Figure 11 shows a water standpipe near a blast furnace. The outside of standpipe was rather badly corroded in 1946. At the recommendation of the paint committee, the standpipe was thoroughly sandblasted, primed with a good zinc-chromate primer, and covered with ⅛-in. of asphalt mastic. This protogragh was taken in June 1952. Some spots are to be reblasted and patched during the summer of 1952, but in general the coating is still continuous and in good condition.

Figure 12 shows a study made by the use of SR-4 strain gages of the dynamic characteristics of coil hooks. As a result of these studies, the coil hooks in use in our plants were redesigned for better safety. This method has been continued in studying the dynamic

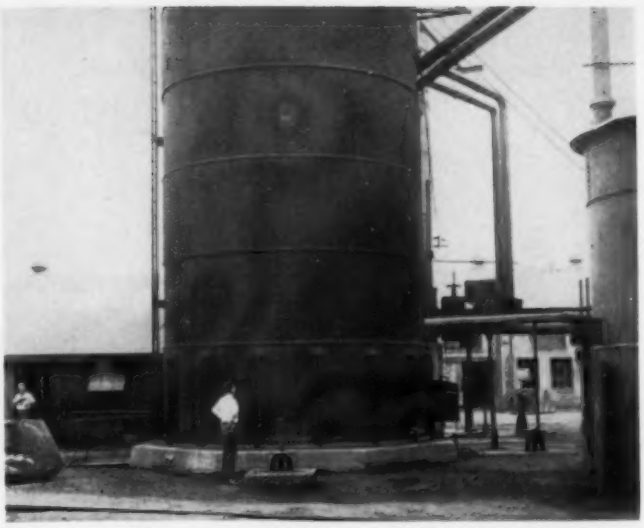


Figure 11 — Proper paint selection is an essential factor in the maintenance man's work.

characteristics of packlifters, new overhead cranes and other lifting equipment.

Figure 13 shows a pickler cradle made of welded

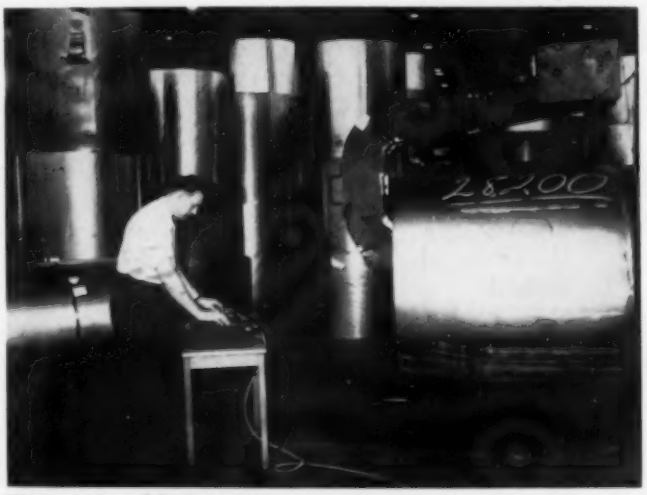
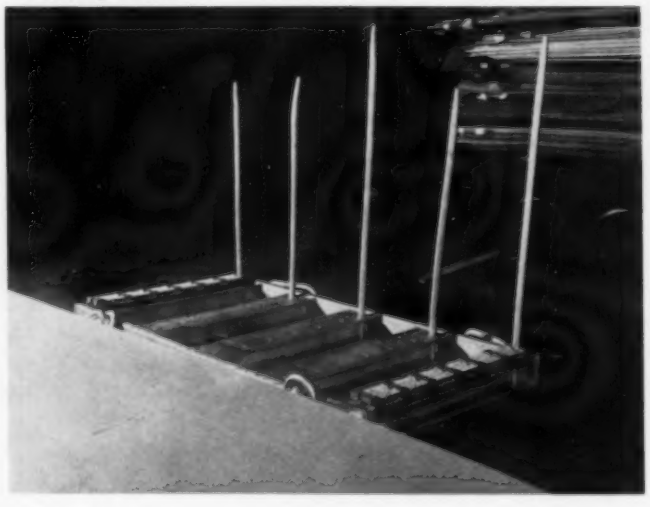


Figure 12 — SR-4 strain gages were used to determine the magnitude of impact stresses.

Type 316 ELC stainless steel. The cradle is used in a batch operation and is exposed to molten salt, hot

Figure 13 — A welded stainless steel pickler cradle is found to give better service than the cast steel cradles formerly used.



dilute sulfuric acid and hot dilute nitric-hydrofluoric acids. It has been found more satisfactory from the standpoint of service life and ease of handling than the more cumbersome cast stainless steel cradle formerly used. The welded cradle may be reversed and used with either side up.

Figure 14 shows the use of a product made by our own company in the plant that makes it. The perforated steel flooring shown here is being used here in an aisleway adjacent to a dip galvanizing department. The pig zinc used in the operation is wheeled over this

Figure 14 — Perforated steel floor will reduce maintenance costs on certain installations.

aisleway in steel-tired buggies. Also, the products galvanized are wheeled out for shipment in the same fashion. A steel flooring such as is shown here can be a saver of maintenance dollars for heavy duty applications.

Figure 15 is a view of an arrangement built at one of the steel producing divisions for the pouring of babbitt bearings. Carefully controlled temperatures and arrangements for bottom pouring, as well as adequate

Figure 15 — Equipment for pouring babbitt bearings is helpful in maintenance work.

facilities for cleaning bearing shells, are available at this plant. Less scrap babbitt and better bearings have paid for the equipment many times over.

Figure 16 shows the journal of an ingot buggy axle. The journals of the axles of this ingot buggy were flame-hardened before installation four years ago. The intro-

Figure 16 — Flame-hardened journals with anti-friction bearings are used on ingot buggy axle.

duction of flame-hardened journals permitted the elimination of bronze sleeve bearings. Anti-friction bearings with no inner races were used. The wear of the flame hardened journals was checked bi-monthly for the first year of operation with calipers. Practically no measurable wear occurred during that period. The change in bearings permitted the diameter of the journals to be increased from 5½ to 6 in., eliminating one fillet and reducing the likelihood of impact failure of the axles. This test is still in progress but sufficient time has elapsed to indicate that reduced breakage, reduced wear and increased ease of operation will more than compensate for the expense of the flame-hardening and the anti-friction bearings.

Figure 17 shows a view of the exit doors on a slab-heating furnace. These doors normally operate at a low-red heat and are subject to considerable impact and abrasion. A cast high-carbon 25-12 stainless steel has been used for this application for some years and has proved satisfactory from the standpoint of eliminating frequent repairs and replacement. This same alloy is used for many other heat-resisting applications.

TABLE II

Dynamic Loading Characteristics of Pipeyard Crane, Fabricating Division

	End of bridge		Center of bridge	
	Heavy coil	Light coil	Heavy coil	Light coil
Weight of coil and hook	21,300 lb	18,600 lb	21,300 lb	18,600 lb
	Recorded overload values in pounds			
Normal pick-up from ground	None	1000-1500	None	1000-1500
Normal lift from above ground	2000-2500	1000-1500	2000-2500	750-1000
Full speed lift from above ground	2000-2500	1500-2000	2000	
Normal brake stop	2000-2500	2500	1500-2000	3000-3500
Plug stop	11,000-12,000	7500	8000-9000	5500-6000
Hoist speed (heavy coil), fpm	45.8			
Lowering speed (heavy coil), fpm	95.6			

Figure 17 — Alloy exit doors give longer life on slab heating furnaces.

Table II shows data accumulated on the dynamic loading of a new crane. The crane was of 15-ton capacity and was used in handling pipe. SR-4 strain gages were emplaced on the carrying arm of a spider used on the crane. The highest dynamic overload was obtained by using a plug stop while lowering at full speed and was about 50 per cent of the static load.

TABLE III

Corrosion Rates of Various Materials in Light Oil Tank, Coke By-Products Plant

Material	Composition, per cent	Corrosion rates in in. per year
Monel metal	68 nickel, 29 copper, 2 iron	0.0092
Carpenter 20	20 chromium, 29 nickel, 2 molybdenum, 3 copper	0.0094
Type 317 ELC	0.03 max. carbon, 18 chromium, 12 nickel, 3.5 molybdenum	0.0182
Armco 17-14 Cu-Mo	17 chromium, 14 nickel, 2.5 molybdenum, 3 copper	0.0185

Table III shows the results of a corrosion test made in the light oil agitator tank of a coke by-products plant. In this tank the light oil fraction is treated with concentrated sulfuric acid, washed and then treated with caustic. The tank had been made of steel and lined with lead. Considerable difficulty had been experienced with cracking of the lead due to creep. This slide shows four materials which would be considered as satisfactory replacements for the lead lined tank, monel metal being preferred.

SUMMARY

The problem of maintenance material application offers countless opportunities for the reduction of maintenance delays and maintenance expenditures. From our experience of the past ten years, we have proven to our own satisfaction that this field of investigation and research is a very fertile one. We know that the work that we have done during these ten years has been productive, yet we also know that in ten years time, we have been able to just scratch the surface. There is much yet to be done.

We believe that our approach to the solution of the problem is one of many that may be used. We do believe that the questions "why" and "what" are essential and that the allocation of failures into one of the four general classifications is very important. We also believe that a "Material Betterment Program" should be executed along with a "Failure Research" program as it is through this means that the best of materials will be made available to the maintenance organization.

The demands placed upon the productive equipment in industry today are great. Delay free operation, at a reasonable maintenance cost, is essential. Delay free operation can be gained, in a major degree, by sound material applications. Such applications can be realized by correcting and improving the material in the equipment of today and then designing the best of material into the equipment of tomorrow.

DISCUSSION

PRESENTED BY

R. J. JOHNSON, Metallurgical Engineer, Republic Steel Corp., Central Alloy District, Canton, Ohio

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GEORGE W. RODGERS, Assistant Superintendent, Mechanical Dept., Bethlehem Steel Co., Johnstown, Pa.

JOHN A. DRGON, Assistant Maintenance Superintendent, United States Steel Co., Irvin Works, Dravosburg, Pa.

R. J. Johnson: Our experience has been parallel to that of the authors in many respects, and we concur that the field of investigation and research in steel plant maintenance is a productive one. We have come to realize that a successful program against failures begins in the engineering department, and that selection and specification of materials is of importance equal to sound mechanical design. Actually, the design of a piece of equipment is not complete until we have indicated the material requirements. We believe that more and better work on materials as specified through the engineering department will go farther in failure prevention than any other approach.

With respect to welding and torch cutting, it is doubtful whether the problem of indiscriminate use of these processes will ever be overcome. This arises through the difficulties in large operations of reaching the many individuals involved and the turnover of personnel.

We were particularly interested in the applications of wire resistance strain gages in the author's plants, and the flame hardening of mold buggy journals. We should like to inquire whether additional installations of this type of journal have been made.

J. B. Whitlock: This particular application on the mold buggy has not been necessary in other parts of our plants since here we completely eliminated the interrace of the roller bearing. However, we have done a great deal of flame hardening work on bearing surfaces of other types.

George W. Rodgers: The authors have presented a clear and concise description of some of the factors that result in material failures and of some of the steps that can be taken to improve the life of expendable materials. We have observed many failures, similar to those described in this paper, that can be grouped into one of the four general classifications. The classification that has given us the most concern in this period of high productive requirements is "misuse or abuse of equipment in operation." It has been necessary in many instances to increase section thickness of machinery parts, redesign equipment, or improve quality of materials used in order to minimize failures.

An inflexible rule has been in effect for many years with respect to welding repairs on items subject to high cyclic stresses or extremely high local stresses. Such repairs are forbidden on armature shafts and crane hooks.

An effective control of misapplication of material for replacement parts has been attained by supplying each of our mechanical repair foremen with a chart of Maintenance Material Specifications. This chart, under such headings as Machinery Steels and Forgings, Steel Castings, Brass and Bronze, Stainless Steel, etc., lists the various types of materials available with a corresponding description of end use. Each order for a replacement item is accompanied by a "Material Questionnaire," which gives the reasons for the failure, the service record, and any recommended changes for proper material application and design before the part is manufactured. This system has proved very effective in minimizing failures because of use of improper materials.

In the material betterment section of the paper, the authors have described some important developments for improving the service life of machinery parts and structures. Of course, asphalt mastic and similar materials have been used for some time for surface protection of tanks, piping and other structures subject to corrosive attack.

However, we feel that the authors have omitted two important phases of material betterment, namely, proper use of lubricants and the application of surface protection against wear derived by fusion welding.

A sound lubrication program, organized and supervised by a lubrication engineer, has a marked effect on increasing service life of machinery parts. Many times failures attributed to poor material, workmanship, or overload can be readily eliminated by change in lubrication practice.

Hardfacing by fusion welding extends, by many times, the normal life of equipment, thereby increasing the efficiency of operations and lowering maintenance costs. Worn parts that formerly were sent to the scrap pile need no longer be discarded. By providing them with a wear or heat resistant coating of special alloy materials, they can become better than new parts, giving a longer extra life of useful service. Among some of the items which lend themselves to hardfacing are the following:

1. Coupling boxes, spindles, pinions.
2. Hot mill shear blades. We have been able to obtain up to 970,000 tons of 8 x 8-in. blooms sheared on a set of hardfaced blades.
3. Wearing plates, skids, furnace runners.

4. Soaking pit tong bits, stripper bits, etc.
5. Rolling mill guides, table rollers, twister rollers.
6. Crane trackwheels. Over 400 wheels have been rebuilt successfully.

This list represents a small part of the items that can be salvaged and/or improved by hardsurfacing. Work of this nature is done under the technical supervision of a welding engineer, who by discussion with the various departmental repair foremen, decides which items are to be hardfaced, which alloy to use for the surfacing operation, and, when installed, he maintains records of service life.

John A. Drgon: The paper on maintenance materials highlights one of the major reasons for operating delays and consequent production losses. It is axiomatic that in order to keep production cost down, one of two things must happen. Either operating cost must be decreased or production increased. Since failure of component parts of operating units is a direct cause of production losses, it is mandatory that we immediately analyze and investigate material failures of functional equipment.

In a good preventative maintenance program it is of paramount importance to develop a so-called failure research program. Supervisors should be trained to have inquisitive minds causing them to continually ask the question, "Why does it happen and what can be done to correct the condition?" The method used in setting up a program of this type depends entirely on the type of organization existing in the respective plants. The nature of investigation generally depends on type of failure encountered and as stated by Mr. Whitlock's paper, may involve anyone from departmental supervisor to metallurgists and design engineers.

Analysis of various types of failures sometimes creates interesting problems and quite often indicates mistakes in design of component parts of operating machinery. This immediately brings the manufacturers into the picture. Too often an oversight on the part of design engineers causes failure in otherwise satisfactory pieces of equipment. A case in point is the experience we encountered on a service unit. In this case, a shaft integral with hub plate was machined from a steel casting. Constant flexing at the base of hub caused fatigue at this point. After several failures of similar units, the cast steel shafts were replaced with forged material, and since then we no longer have failures of these parts. Mr. Whitlock's illustration showing the broken clevis is a common type of failure occurring, I venture to say, at some time or other at most steel mills. Although we do not generally permit original fabrication of this type, we quite often find that some ambitious maintenance man fabricates a lifting device with welded clevises. Promiscuous welding of this type is being discouraged since too often they are not properly stress relieved and therefore cause serious safety hazards.

It is enlightening to note Mr. Anderson's use of the SR-4 gauges to study the dynamic characteristics of lifting equipment. This should be greatly beneficial in the proper design of this type of equipment. We have had several failures of lifting equipment in our plant which was caused by improper design and improper fabrication methods. In all of these cases we have had excellent cooperation with manufacturers to correct conditions which could cause extremely dangerous safety hazards along with high maintenance costs.

Unfortunately, too often, manufacturers develop excellent equipment design, use good materials and then use inferior fabrication or assembly methods in order to reduce costs. The manufacturers should recognize their responsibilities in this respect since they very often cause not only equipment failures but serious safety hazards.

Since maintenance materials are generally around 55 per cent of maintenance cost, too much cannot be done in the investigation and classification of various types of failures. Very often changes of design are required along with material betterment to prevent costly production losses and high maintenance cost.

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MAINTENANCE PAINTING OF STEEL AND COKE OVEN PLANTS

By S. C. FRYE
Research Engineer
Bethlehem Steel Co.
Bethlehem, Pa.

. . . . painting is a recognized tool of preventive maintenance . . . .

▲THE invested capital of the steel industry of the United States is about $6,000,000,000, mainly in buildings and equipment made of steel or other corrodible materials which must be protected by painting. Thus maintenance painting of steel plants does not differ from other painting in that the main purpose is to protect against corrosion. Maintenance painting may be divided into two classes, outdoor painting for the painting for the outside of buildings and outdoor equipment, and inside painting for the inside of buildings and for machinery, etc., which is located inside of buildings. Inside maintenance painting is not only carried on to protect the interior of buildings and machinery, but also for good housekeeping, to provide better lighting and to improve employee morale.

In recent years the managers of our steel plants have become increasingly aware of the value of good housekeeping including plant layout, neat storage of spare materials, clear open passageways throughout the plant, inside and outside of buildings, and the neat appearance and protection of buildings and equipment. They are taking great pride in all of this. Even a casual visitor to any well maintained steel plant is immediately impressed by the neatness and orderliness in everything he sees. Maintenance painting has contributed a large share of this aspect of good plant management.

In all maintenance painting the aim is to repaint before the old paint has deteriorated to a stage where it has to be entirely removed. This is done by periodically applying a single new coat of paint over the cleaned old paint. The ordinary length of such a period in a steel plant is about three years, both for outside and inside painting. This procedure of repainting at intervals by applying a single coat of paint has been found to be much cheaper and to give better protection and appearance than waiting a longer period until the old paint has to be removed, the structure cleaned, and then coated first with a primer paint and finally with a finish coat of paint.

The most important thing about any type of painting is the proper preparation of the surface. One can use a high quality paint and nevertheless get poor results if the surface is poorly prepared. On the other hand, good results can be obtained with a medium quality primer paint if the surface is well prepared. The type of surface preparation to be used depends on the job.

OUTSIDE PAINTING

In outside painting it is the general aim to repaint after regular short periods instead of after the paint has completely failed. However, with some equipment it is not feasible to paint after a predetermined regular interval to say three years. For example, a blast furnace cannot be repainted while it is in blast. This can only be done when the blast furnace is shut down as for relining which may occur after five or even ten years. After such a long period, complete removal of the old paint and repriming and repainting is usually neces-

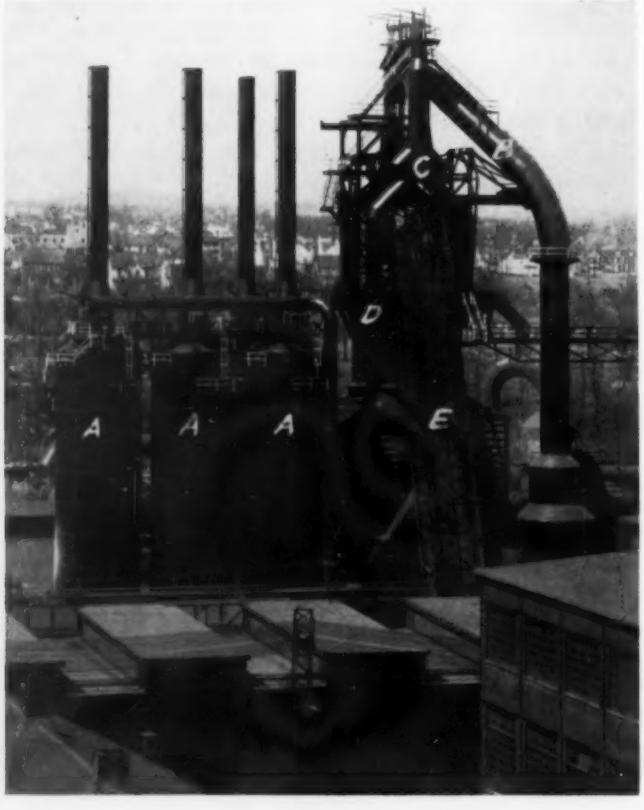
sary. Here thorough cleaning is advisable by sandblasting and chipping, particularly on blast furnace stacks, skiphoists, trestles and stock bins.

Blast Furnaces—Figure 1 shows a newly painted blast furnace and some of its auxiliary equipment. The stoves (A), downcomer (B), uptake (C), and the blast furnace stack itself (D) were sandblasted. The skiphoist (E) was sandblasted and chipped with chipping hammers to remove caked ore or other materials that collect on the skiphoist. The ore trestle and stock bins, not shown in this view were also cleaned by sandblasting. Chipping hammers were also used where necessary to remove caked and thick deposits of ore, limestone or coke usually found on these structures.

After cleaning, the steel was primed with a primer, the pigment of which was lead chromate, iron oxide and extender, and the vehicle of which was raw linseed oil and spar varnish. The finish coat was a black alkyd resin exterior paint. A more detailed discussion of these paints is given in the section on Paints later in this chapter.

Coke Oven Plants — The maintenance painting of coke oven plant buildings and equipment presents a very difficult problem because of the severe corrosive conditions usually found in coke oven plants. Around coke oven plants, preparing the surface of the steel before painting by hand wire brushing followed by painting with ordinary paints is entirely inadequate and will give a paint life of only months instead of years. However, if the surface as prepared by sandblasting is then primer painted with a good primer, and is further given a mastic finish coat, the mastic will last five years and even longer. The mastic finish coat may be either the asphalt emulsion or the natural bituminous resin-asphalt type. A coal tar finish coat may also be used instead of mastic but in this case no primer paint can be used because the primer will "bleed" through the coal tar finish coat.

Figure 1 — The parts of the furnace shown here were finish coated with black synthetic resin enamel.



If there is any objection to the appearance of such black mastic or coal tar coatings, a colored finish paint may be used. But such a paint must be chemically resistant, and phenol-formaldehyde, vinyls and chlorinated rubber paints offer such resistance, although they are somewhat more costly than the black mastic or coal tar paints.

Hot Stacks—Hot stacks present another interesting painting problem. Such stacks may be divided into two classes, those with a high stack temperature, above 450 F to as high as 1200 F, and those with a low stack temperature, below 450 F. These temperatures refer to the outer metal surface of the stack, which is to be painted, and not to the temperature of the gases inside the stack. The temperature of the gases may, of course, be much different than that of the metal on the outside of the stack.

With stacks having a stack temperature as high as 800 F, either aluminum pigmented silicone resin or lead borosilicate-synthetic resin gives good results, so that repainting need not be done at more frequent intervals than about two years. With hotter stacks from 800 F to about 1200 F, a pitch mixture combined with lead borosilicate may be used, and here too the interval between repainting may be as long as eighteen months. While there have been failures in stacks painted as described above, most of the failures have doubtlessly been caused by vibration in the stack and not by any shortcoming of the paint. It is, therefore, very necessary to insure that stack vibration is eliminated in so far as possible.

Stacks with low stack temperatures below 450 F may be painted with oleoresinous heat-resistant paint or with lead borosilicate-synthetic resin type paint. These paints usually contain an aluminum pigment. These paints have been found to give good service and painting is only required at two year intervals.

The stacks with low stack temperatures as well as those with high stack temperatures are painted when they are not in use, at a time when the stack temperature is close to atmospheric temperature. The stacks must be thoroughly cleaned by sandblasting. They should be given two coats of heat-resistant paint. The second coat is applied about two weeks after the first coat. The heat should be off the stack but the stack should be somewhat warm, not too cold.

Roofs—A very common type of roof in steel plants is made of corrugated sheet steel covered with asphalt and asbestos or asbestos and aluminum paint. Such roofs can be maintained by spraying, preferably with coal tar solutions or with mastic solutions. The period between sprayings may be as long as ten years.

Another very common type of roof is made of galvanized sheet. The critical parts in such roofing are the laps where the sheets are joined by fitting one over the other. Moisture tends to collect in these laps so that in these over-lapping areas the corrosion is much more severe than in the body of the sheet. This problem is handled by spraying the entire surface of new galvanized sheet with a zinc dust-zinc oxide priming paint,

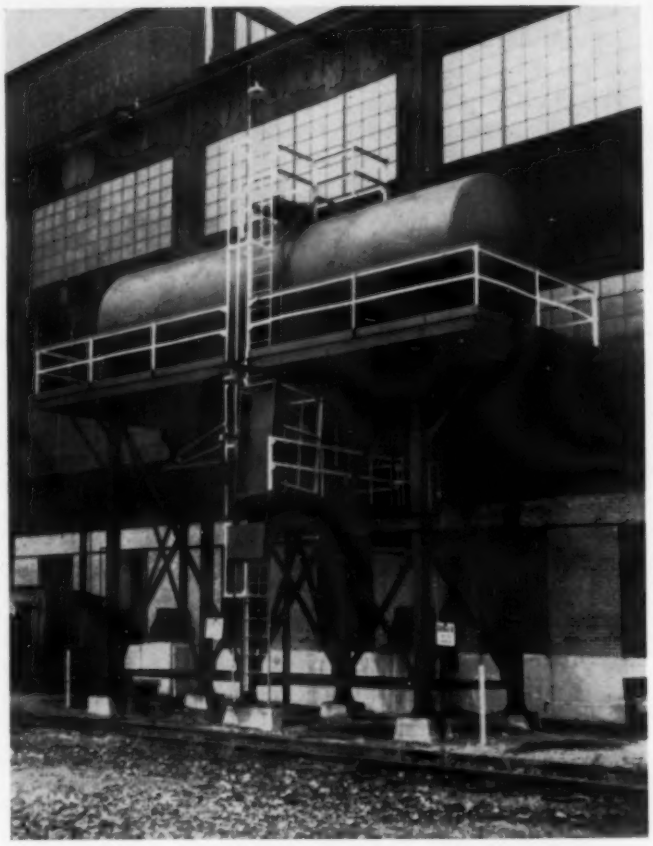


Figure 2 — An elevated acid tank and its structural steel supports are coated with mastic. The light colored hand railings are painted in the bright yellow "safety" colors.

before the sheet is stored or laid on the roof or siding. This priming paint has been found to eliminate corrosion in the laps. As stated, the priming paint must be applied before the sheet is laid, as it is practically impossible to eliminate corrosion at the laps after the sheets are laid without previously giving them such a priming paint. After these primer painted sheets are installed, they can be further protected with a finish paint. Spraying with a coal tar solution or with a mastic solution or with an ordinary finish paint such as a black synthetic resin enamel is suitable for this purpose. Even after such treatment it is advisable to repaint with another coat of finish paint every five to eight years.

On older buildings, "built-up" roofs made with wood, cement or asbestos decking covered with tar paper coated with tar are commonly used. These are generally maintained by recoating with coal tar solutions or mastic solutions at twelve to fifteen year intervals.

Another type of roofing and siding that has been used to some extent is made of porcelain enameled steel. This type is high in initial cost but requires practically no maintenance. Such roofing or siding is not painted. The same is true of stainless steel roofing and siding. Some steel plants have used 12 per cent chromium steel sheet for the roofs and siding of their mill buildings.

Siding—In many of the newer mill buildings the sides are also so constructed as to have large areas of sheet steel on the outside. This sheeting is protected from corrosion in much the same way as the sheeting for roofs, that is, with asphalt and asbestos or asbestos and aluminum paint. Sheet so protected, termed "protected metal" can be purchased, and this is usually done, rather than to paint the sheet after it is erected. After erection such protected metal siding is maintained by spraying with coal tar solutions or with mastics at periods of about fifteen years.

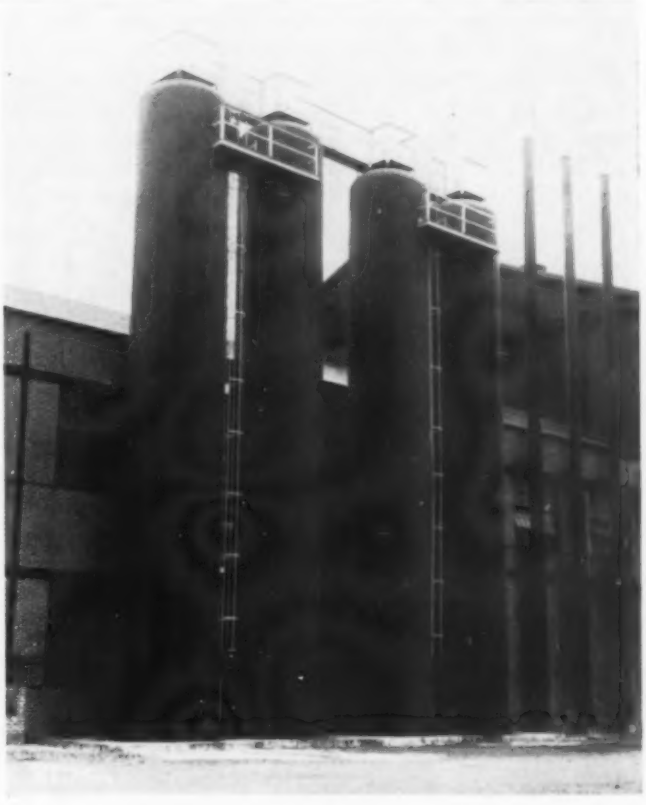
Galvanized sheet is also used to a large extent for siding. Such sheet is handled exactly as galvanized sheet for roofs. The sheet is completely sprayed with zinc dust-zinc oxide primer before erection. After erection it can be finish painted with coal tar paint or an ordinary finish paint such as black synthetic resin enamel at intervals of about four years.

Outside Equipment—The type of painting on outside equipment such as tanks, transmission towers, etc., depends on the type of finish to be applied and the corrosivity of the atmosphere in which it is located. Figure 2 shows an elevated acid tank. The tank and its structural steel supports were primer painted and then finish painted with mastic. It should be noted that the safety hand railing and ladders are finish painted in yellow. The siding on the building in the background is corrugated protected metal.

Figure 3 shows a mastic coating on steel towers used in purifying annealing gas. Here again hand railings and safety ladders and cages are painted yellow. The small diameter stacks to the right of the towers are at atmospheric temperature and are painted with black finish paint as is the exposed structural steel in the side of the brick building. This building has a galvanized metal roof coated with zinc dust primer and then finish painted with a coal tar solution.

Figure 4 shows another instance of the use of mastic coating; the mastic coated equipment here is a ventil-

Figure 3 — Steel towers used in purifying annealing gas are coated with mastic.



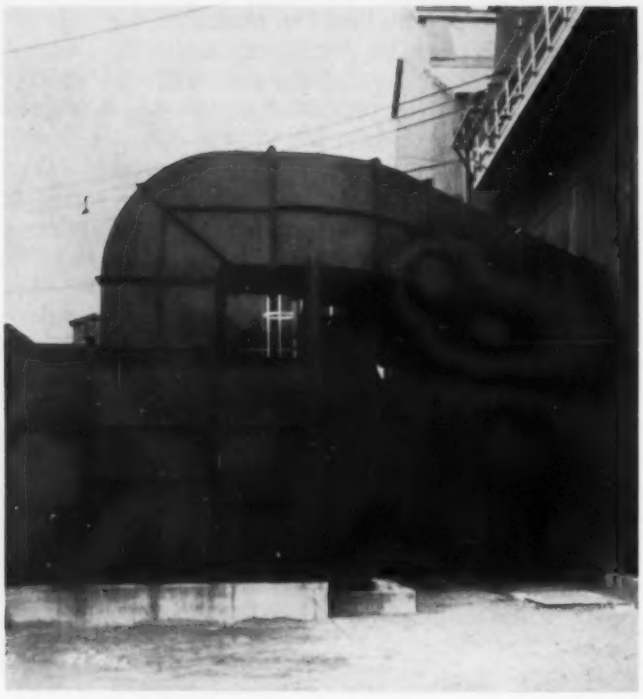


Figure 4 — A mastic coat is used inside and out on the ventilating system for the motor room of a cold reducing mill.

ating system for the motor room of a cold reduction mill. Prior to coating with mastic, leaks were continually being found in the sheet steel used in its construction. No leaks have been found, however, after this structure was coated inside and out with mastic. The main building siding is corrugated protected metal. The structural steelwork is finished with black synthetic resin enamel.

The preservation of large spare parts, usually stored outdoors exposed to the atmosphere, is becoming increasingly important as these parts become harder to obtain and increase in dollar value. There has been initiated a program of primer painting all spare parts that will be stored outdoors with one and even two coats of primer as soon as the spare parts are received or fabricated.

INDOOR PAINTING

While in indoor painting, protection from corrosion is still a very important consideration, nevertheless more attention must be paid to appearance. The painted parts must be clearly seen and distinguished one from another and from the background. They must appear clean, and in conformity with safety regulations they are frequently painted with certain standardized colors. Consideration must be given to the reflectivity of the paints and whether they will aid in providing good lighting. There has been a noticeable trend to the use of lighter colors in steel plants, such as whites, aluminum, light grays and greens as distinct from the dark utilitarian colors such as black, dark grays and greens commonly used in the past.

In maintaining indoor paints the practice is to employ periodic repainting at fairly frequent intervals of about three years and not to wait until the paint is completely deteriorated. In such periodic repainting it is sufficient to merely steam clean the previous paint or to wash it with solvent preparatory to repainting. This not only cleans the surface but removes the gloss of the old paint and thus provides better adhesion for the new paint. Only one coat of finish paint is applied.

Interior of Buildings—Sheet steel "protected metal," galvanized sheet steel, brick, and wood are usually the materials used for the interior construction of mill buildings. "Protected metal" sheet steel for interior use is either coated with asbestos and then with asphalt or with asbestos and then with aluminum paint. The asphalt coated "protected metal" is usually not repainted at too frequent intervals and can be repainted with coal tar solutions to rejuvenate the asphalt coating. If, however, regular paints are to be used the asphalt coating must be coated with a sealer to prevent "bleeding." "Bleeding" is a term used to describe the action whereby solvents in regular paints dissolve asphalts and coal tar and then deposits them in the paint film as the solvents evaporate from the film. Severe discoloration of paint films can occur unless the asphalt or coal tar is sealed from the paint film. Aluminum paint with an oleoresinous vehicle has been found to be an effective sealer in most cases. However, an aluminum pigmented sealer with an alcohol soluble resin as the vehicle has been an effective sealer in all cases. The aluminum sealer can be the finish coat or other interior finish paints can be applied over it.

Galvanized sheet steel, as stated previously, is primed both sides with zinc dust-zinc oxide galvanized metal primer before erection. This means that the surface of the sheet inside the building is already primed and ready for painting with interior finish paints.

Brick construction inside mill buildings is a great collector of dirt and dust which gather in the pores of the brick. The brick can be first primed with a masonry primer sealer and then finish painted with almost any desired finish paint.

Wooden buildings are not usually found in steel plants but wooden roof decking is fairly common, particularly in the older mill buildings with "built-up" roofs. This wooden decking, if painted at all has heretofore been painted with ordinary primers and finish paints. There is, however, a problem of fire protection, particularly in buildings having wooden roof decking and no means of protecting it against fire. To provide protection to these large interior wooden areas the use of fire-retardant paints has materially increased. After extensive testing, the fire-retardant paint being used is the puffing type which, when exposed to heat and fire, expands to form an insulating blanket over the wood, thereby keeping the temperature below the combustion temperature of the wood.

Machinery and Equipment — Equipment in buildings, such as rolling mills, motors, machine tools, etc., is handled in the same way as building interiors. Practically all machinery and equipment is received already painted so that all it needs is repainting. The practice then is to clean the surface before repainting by either steam cleaning or solvent washing. A single coat of finish paint is then applied, usually at intervals of seven or eight years. Functional painting so as to clearly dis-

tinguish moving parts and the parts of the machine which do the actual work has come into increasing use.

Pickling Tanks—Pickling tanks and other chemical equipment has been too long regarded as unpaintable by maintenance painting supervision. When it was finally realized that this equipment was chemical equipment and had to be protected with chemical resistant paints, then maintenance painting troubles practically disappeared. The principal chemical resistant coatings which are used on pickling tanks are the phenol-formaldehyde types, the vinyl types, rubber base types, and the coal tars or the mastics.

It is not feasible to periodically repaint pickling tanks by merely applying another finish coat over the old paint, because it has been found that the paint surface usually has become saturated with the pickling acid. It is, therefore, necessary to completely remove the acid contaminant and also the old paint. This is done by washing the painted surface with water to remove excess acid, then steam cleaning to remove traces of acid that the water wash did not remove. The tank is then sand or grit-blasted to bare metal and primer painted immediately with a chemical resistant primer if finish paints other than coal tar solutions will be used. Coal tar solutions should not be applied over primer paint because "bleeding" will develop. At least three coats of either the phenol-formaldehyde, the rubber base paints or coal tar solutions and at least four coats of vinyl type paints should be used. If mastic is used, it should be at at least ¼-in. thick, applied in one application.

The interval between the repainting of pickling tanks has been found to be about seven years.

Safety Colors—The use of safety finish paints applied as maintenance painting is an important part of any safety program. Most plants follow the American Standards Association standard safety colors for fire protection, mobile equipment, hand railings, crane blocks, emergency first aid equipment and colors denoting the materials carried in pipe lines. Care should be taken, however, against the promiscuous use of safety colors. For this reason the safety department should cooperate with the maintenance painting department in deciding whether the safety colors designated for a particular purpose should be used at any particular location.

PAINTS

Most maintenance painting being on steel, a large proportion of which is exposed outdoors, the steel has to be properly cleaned and primer painted. This applies only to the first painting and not to periodic repainting where a primer paint is, of course, not applied. The customary and most practical method of cleaning for such primer painting on new or unpainted steel is sandblasting so as to remove loose scale and rust. The primer paint should then be applied as soon as possible before new rust forms.

Where periodic repainting cannot be done, as for example on blast furnaces, the old paint must be removed before repainting. This is also done by sandblasting but here the cleaning effected is not so good as on new or unpainted steel, since some of the tightly adherent old paint is not removed. Where sandblasting cannot be done, as on steel window sash, the cleaning has to be done by wire brushing which does not clean as well as sandblasting, but nevertheless gives a fairly satisfactory surface for primer painting.

Primer Paints—There are two main constituents in a primer paint, the pigment and the vehicle.

The pigment will be rust inhibitive if it contains substances like red lead, basic lead chromate, or zinc chromate. These substances have an oxidizing effect on steel, making it somewhat passive so that rusting is retarded.

Extensive testing has indicated that three principal kinds of primer pigments give good service. The oldest of these is red lead and for maintenance painting this is usually mixed with about 50 per cent or more of iron oxide and other inert "extenders." The other two types are basic lead chromate and zinc chromate which are also mixed with about 50 per cent iron oxide and other extenders.

The vehicle should be compatible with the pigment. It should completely wet the steel surface and tend to displace moisture absorbed at the steel surface. After drying, the vehicle should be impermeable to moisture and afford a good base for the finish paint.

A vehicle containing raw linseed oil, a spar varnish or synthetic resin varnish and drier can be made to conform to most of the above requirements. Raw linseed oil will wet a steel surface, displace adsorbed moisture and will, to some extent, provide impermeability. Varnish or synthetic resin will provide more impermeability, film hardness and drying ability. Additional drier will improve the drying time of the vehicle.

We use primers defined by Bethlehem Steel Co.'s MM-1-51T Specification for Maintenance Primers. This specification was written on the basis of extensive testing of both pigments and vehicles for use in maintenance primers. A choice of three types of primers, namely the red lead type, basic lead chromate, or zinc chromate is given, leaving the choice to individual preference. Through the use of such a specification the quality and composition of primers can be economically maintained.

Finish Paints—Finish paints, regardless of color, whether for interior or exterior use must provide good appearance, impermeability to moisture, protection to the primer which in turn protects the steel, a good surface for future repainting and adequate drying. If a glossy finish paint is used, it should be able to retain its gloss for practically the life of the finish paint.

Our black paint is defined by Bethlehem Steel Co.'s MM-2-51T Specification for Black Exterior Paint. Here again, a choice of two major types is given based on individual preference. Type I of the specification is a varnish vehicle, black finish paint, while Type II is a synthetic resin vehicle, black finish paint. Both have given very good service. but based on field and laboratory tests, preference is being given to the synthetic resin type finish paint because of its better appearance and slightly better durability.

Another paint used by us is covered by Bethlehem Steel Co.'s MM-3-51T Specification for Ready-to-Mix Aluminum Paint (Non-Heat Resistant). Type I of

this specification, aluminum flake paste with an oleoresinous vehicle has found almost universal use in steel plants. It has been used as interior and exterior finish paint, as a sealer over asphalt or coal tar and as a primer for wood surfaces.

Type II, aluminum flake paste with a synthetic resin vehicle has been used mostly on outside equipment where appearance is the prime factor in the choice of aluminum to be used.

Also used is a paint described by Bethlehem Steel Co.'s MM-4-51T Specification for Ready-Mixed Aluminum Paint (Non-Heat Resistant). This specification provides aluminum paint exactly similar to the aluminum paint in Specification MM-3-51T. In some cases it has been found preferable to use aluminum paint with the aluminum flake already mixed in the vehicle when the paint is received for use. However, since some aluminum flake have a tendency to lose brightness when the mixed material is stored, this specification was written to provide an aluminum paint equal in brightness to the ready-to-mix material.

Black and aluminum paints are by no means all of the finish paints used in steel plants. These two paints, however, comprise, by far, the major portion of finish paints used.

Mastics—The use of coal tar and other bitumin base materials is increasing as their value in protecting against severe corrosive conditions is being more fully realized. Protection is afforded by their inertness to corrosive attack and the thicknesses in which they are applied. For example, mastics are usually applied at a minimum film thickness of ¼ in. and heavier films can be readily built-up. Coal tar products, on the other hand, are usually applied so as to obtain film thicknesses from 0.04 to 0.01 in.

Mastics generally are made of combinations of gilsonite which is a natural bitumin and mined as such, petroleum asphalt and mineral or earthen fillers. A special type of mastic is a mastic emulsion with water as the solvent.

Surface preparation is very important in the application of mastic coatings. Sandblasting is used wherever possible. Primer paints can be used as primers for both the regular mastics and also for the mastic emulsion. If sandblasting is not possible, then a primer must be used, since mastics tend to work under any scale that may remain on a steel surface not sandblasted. Primer paints must be used under the mastic emulsion type since the water contained in the emulsion will start rusting of the steel surface.

Coal tar solutions, while not applied in film thicknesses as heavy as those for mastics, also give good protection against corrosion. However, when exposed to direct sunlight, some coal tar solutions have a tendency to crack. In such cases surfaces coated with coal tar solutions may be protected by coal tar emulsions which do not have any tendency to crack in direct sunlight.

Surface preparation is also very important for good performance of coal tar solutions. Sandblasting is almost mandatory for good performance. Coal tar solutions cannot be used over primer paints since the solvents in the coal tar soften the primer and destroy its adhesion to the underlying surface. Coal tar emulsions, however, require the use of a coal tar primer or a coal tar solution as a primer before application.

Records—Painting is no different than any other maintenance job in that accurate records must be kept. It is felt the minimum records kept should include the following:

1. Date.
2. Job number.
3. Equipment or building being painted.
4. Man-hours.
5. Type of cleaning necessary.
6. Quantity and quality of paint.
7. Atmospheric conditions during painting.

Each job requires planning and scheduling. Material is ordered if not already in stock. A safety analysis is made and every hazard connected with the job is emphasized to maintenance painting supervision with definite instructions that these hazards be pointed out to each man on the job. An analysis is also made as to whether rigging or scaffolding should be used where such extra equipment is necessary.

Maintenance painting should be a recognized tool of preventive maintenance which, through the cooperation of operating and maintenance departments, will permit the scheduling and planning of painting as an integral part of maintenance work.

DISCUSSION

PRESENTED BY

C. E. PRITCHARD, Superintendent of Mills, Alan Wood Steel Co., Conshohocken, Pa.

S. C. FRYE, Research Engineer, Bethlehem Steel Co., Bethlehem, Pa.

JOHN S. MORRIS, Supervisor Construction and Centralized Maintenance, Lukens Steel Co., By-Product Steel Div., Coatesville, Pa.

C. E. Pritchard: I would like to ask Mr. Frye what experience he has had with paint systems used on units such as machine tools, where the unit in service operation is subjected to chipping as the result of the operators dropping wrenches, etc., on the paint? As might be expected, this localized chipping condition tends to detract from the appearance of the machine tool.

In the proximity of coke quenching stations, what experience have you had with paint systems suitable for such equipment as coke quench cars? In locations such as boiler houses or pumping stations, where you have reinforced concrete ceilings exposed to escaping steam and the tendency of that surface to spall out—what particular preparation, if any, has been used to prevent this spalling condition from extending further?

The question of surface preparation by such means as sandblasting has in turn been found to offer several associated problems, unless the ramifications of same are thoroughly understood. Would you care to discuss your personal feelings in this regard?

S. C. Frye: Regarding Mr. Pritchard's question as to painting of machine tools, where you have quite a bit of chipping, most of our equipment has been painted with resin bases which have quite a bit of resistance

to cracking and chipping. It will pass an impact test of a weight of about 2 kg falling 3 ft without cracking.

Member: On new painting, or on repainting?

S. C. Frye: On repainting. As to the coke-quenching stations, coke-cars, etc., the practice at Bethlehem has been to clean them thoroughly, and in these cases this is very important, by sandblasting and chipping, and to coat the quenching cars with a natural resin gilsonite-petroleum asphalt mastic solution.

As to concrete spalling, I have no experience by which to answer that question.

As to the question of surface preparation by sandblasting, that, I think is a topic in itself which I can hardly go into here, but will only mention its various aspects: sandblasting and the means of doing it, the type of equipment, the type of sand, whether sand should even be used (there are many other things which can be used), speed nozzles, pressures, air-pressure, whether you can re-use the cleaning materials, whether it is economically feasible to re-use them, etc.

John S. Morris: I would like to ask what experience you have had with painting Bunker "C" fuel oil tanks? There seems to be a difference of opinion as to whether it is best to use an insulating or non-insulating paint. The insulating paint would prevent a certain amount of heat absorption from the sun on hot sunshiny days, probably requiring a little more steam to maintain the required temperature at that time. On the other hand at night and on the cold winter days it would probably prevent a considerable loss of heat via radiation.

I would also like to ask what type of paints you recommend for steel buildings where you have both acid and caustic fumes present?

S. C. Frye: Regarding Mr. Morris' question on fuel oil tanks, most of the tanks in the Bethlehem organization are usually painted black. A lot of the oil companies have gone into the mastics. As to acid and alkali fume conditions, we have gone to mastics and we are now making extensive and exhaustive tests on the use of synthetic rubber maintenance on those. Under those very conditions we have found them promising. They are costly, that is, the paints themselves are costly—but on the other hand, our data have indicated that of the ordinary cost of painting, 25 per cent can be allotted to the cost of the paints.

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CHROMIUM PLATING IN STEEL PLANTS

By JOHN B. ALLEN
and
JEROME D. TULLOCH
Chromium Corp. of America
Chicago, Ill.

. . . . chromium plating has been successful in many applications in increasing service life and lengthening working time of equipment. . . .

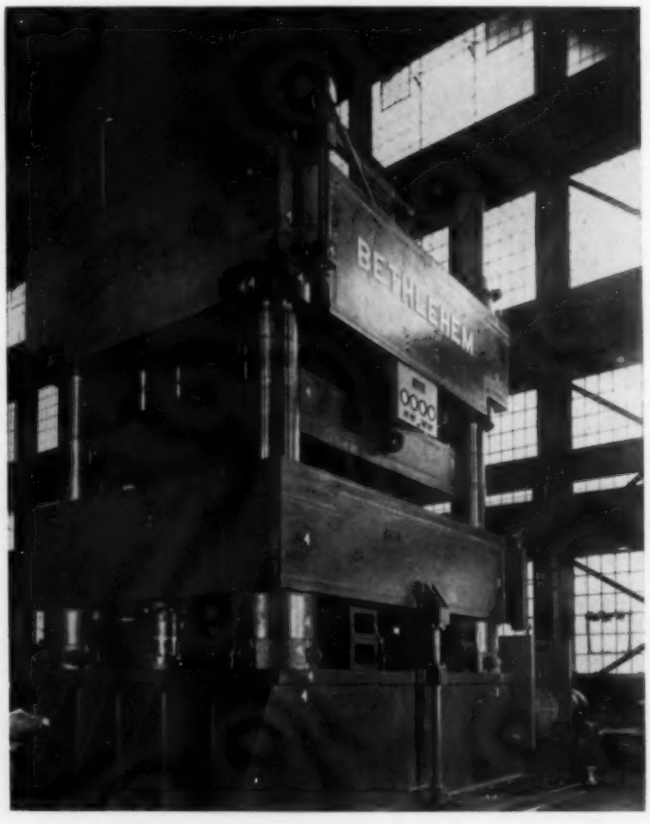
▲ THE purpose of this article is to acquaint iron and steel mill personnel with industrial electro-plating as applied to processing equipment. Any metal which can be electro-deposited has potential use in preserving production equipment, reducing cost of operation and maintenance, and in improving the product itself. This paper will concentrate on chromium plating as the most widely used process in the field of industrial application. Nickel and copper depositions also have valuable uses, and a few will be mentioned herein.

It has been several years since the iron and steel industry has received a formal report on the progress of chromium plating. In the meantime, established applications have been expanded, new applications developed and many mills have incorporated chromium plating in their preventive maintenance programs. Furthermore, advances in the technique of applying chromium by electro-deposition on the base metals and alloys and the existance of equipment for handling heavy and unusual components have greatly expanded the potential field of use. For example pieces weighing from five to forty-five ton are being chromium plated today with increasing regularity.

In the metals industry, chromium plating is being used in mining operations, through all forms of basic processing, to finishing and metal working operations. We will describe successful applications in virtually all phases of iron and steelmaking, and illustrate a few typical installations. Performance records of some of these installations will also be cited.

Starting with the coke plant, the development of a successful application on cross-head liners has resulted in trouble-free operation where gases, condensate and abrasion made for continuous replacement. The cast-iron liners are chromium plated approximately 0.008 to 0.010 in. thick and finished to a smooth, semilustrous surface within acceptable limits. Corrosion is eliminated and the ability of chromium to prevent galling and seizure maintains the liner in top condition with no loss of efficiency for extended periods. Other applications here include cross-head guides, power pistons and quenching valve piston pots.

Figure 1 — This 4000-ton hydraulic press designed to hot-form body parts for railway car construction has a main actuator ram with a chromium plated casting 58-in. diameter × 76-in. face, weighing 85,600 lb.



In the blast furnace division, a number of potentially valuable applications are on trial such as bell rods, bucket guides, control valve rods and hopper segments. Soon to see service will be some one piece chromium plated revolving hoppers which have been plated on the outer surface to combat wear and corrosion thus maintaining an efficient seal and free rotation without tearing out the sealing rings. Experimental work has also been done on mud gun liners, taking advantage of the extreme hardness of chromium for reduction of wear and to maintain efficiency.

In the open hearth division, chromium plating has potential use on the hydraulic equipment as always, and is also being used extensively on ladle crane axle bearing surfaces. The crane axles are being plated regularly for wear resistance to combat the adverse effect of dust in the bearings.

The power division has been the scene of one of the earliest and most successful chromium plating applications in the industry. The original plated gas engine piston rod reported to this assembly in 1948 was still in operation after six years of continuous service. Since then, eight more gas engine piston rods have been chromium plated and are in successful operation. The application can be highly recommended.

Other applications worthy of trial and use in the power division would consist of pump sleeves, cylinder liners and plungers for auxiliary pumps and control valve rods.

The rolling mill division, specifically slab and billet mills, have been the scene of many successful chromium applications in applied hydraulics particularly. Here the plating has been very successful on roll balance plungers, shear rams and pull backs, accumulator and intensifier plungers and ingot tilter plungers. These units are all subject to severe operating conditions, exposed to hot flying scale, condensate and corrosive waters, silt in the hydraulic system and continuous wear. Components produced from the standard materials such as cast iron, cast steel, chilled iron or forged steel soon require frequent servicing in the form of repacking and eventual resurfacing or complete replacement. These delays are costly, not only from the maintenance standpoint but, more important, in lost tonnage which can never be actually regained.

A detailed performance record report of a chromium plated main ram in a 44 in. slab mill shear, 3000 tons capacity, presents an interesting and convincing case. Grinding of the ram was an annual affair, but within the one year period repacking gradually degenerated to a weekly schedule. The ram, 10-ft long, 40-in. diameter over a 48-in. span and 24-in. diameter on the remaining 6-ft was chromium plated and installed in July, 1948. In the four ensuing years, the ram was repacked four times on the 40-in. diameter and twice on the 24-in. diameter. Once, within a year of installation, a cold slab overloaded the shear, caused a cocking of the ram and galled the chromium surface on one side. A local repair in the form of polishing, spot welding and plating was performed "on location" without removing the ram from the cylinder. In June of this year, a spare ram finally was installed and the original ram is now being replated for later use.

At this point, emphasis may be placed on the local repairs made to this chromium plated ram in the field. In other words, damage to the chromium plated surface does not necessarily mean a major shutdown or complete replacement of the parts. Repairs can be effected in a twenty-four to forty-eight hour period. Another consideration which cannot be measured in dollars and cents or tonnage production is the fact that in this particular installation, the pits adjacent to the shear have remained relatively dry, making for safer and more comfortable working conditions during actual operation or repairs to tables and other equipment.

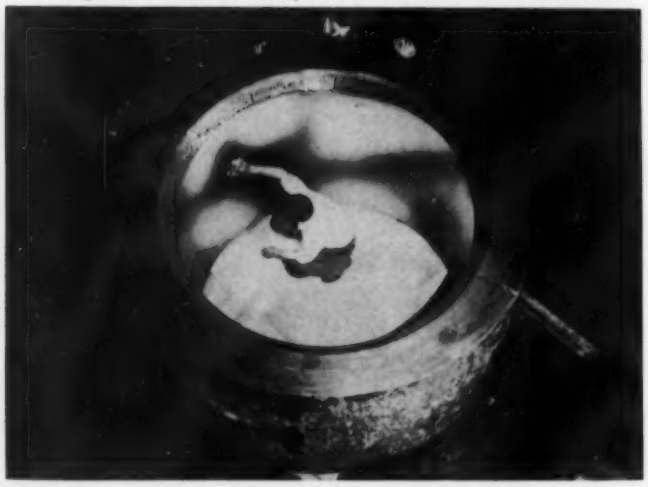
Figure 2 — A 3000-ton shear with a chromium plated ram has, over a period of four years, saved thousands of dollars in regrinding costs alone. Chromium plating thickness is 0.010 and 0.012 in. radially over both the 24 and 40-in. diameters. The ram is 104-in. overall.

Figure 3 — Chromium plated plunger which actuates the hot shear shown in Figure 2. The mill holds a plated spare in reserve because a chromium plated plunger is essential to proper performance of the line.

From the heavy rolling mills we may now proceed to the so-called finished product mills such as the merchant mills, structural mills, rod and rail mills and forging plants. Time will not permit a detailed report of potential applications in all of these plants so we will mention some in passing before presenting a detailed report on one of the most successful and outstanding installations. Again, crane axles and hydraulic equipment present excellent possibilities for maintenance cost reduction and keeping production schedules at highest levels. Other possible uses include web rolls, guide rolls, toe pads and roll necks. Preliminary trials indicate successful application of chromium to roll necks for use in fabric bearings with water lubrication. More will be known about this in months to come.

Forging plants have probably seen the most extensive use of chromium plating among all of the so-called specialty mills. This is probably due to the peculiar value which chromium plating has in the field of applied hydraulics. Just about every conceivable application has been exploited from valve parts to main actuating cylinders and rams. One of the most spectacular applications for chromium plating from the standpoint of performance as well as size involves the plating of the main cylinder of a 10,000-ton forging press. The cylinder, a steel casting, weighs thirty tons and has a bore of 6-ft, the ram carries the packing making the cylinder wall the important bearing surface. The cylinder was first chromium plated and installed in July of 1948, and resulted in very satisfactory savings in maintenance expense as well as a marked improvement in tonnage produced. The leather packing rings used in this cylinder cost approximately $135 each and before the cylinder was chromium plated, replacement every three to six weeks was considered necessary. Downtime to make the change ran about forty-eight hours for a full crew and tonnage losses accepted as a matter of course. After plating, repacking was reduced to a quarterly operation which could be correlated with other major repairs, and production schedules were so improved by this and other chromium plating applications on the line that additional equipment in the machining and finishing departments of the same plant, had to be acquired to keep pace with the tonnage attained.

Figure 4 — Progressive corrosion of the bore of this cylinder was eliminated by chromium plate while maintenance shutdowns were reduced 4 to 1. It is the main cylinder of a 10,000-ton press, 6 ft in diameter, 54,000 lb in weight, and the bore is plated 0.030-in. on the diameter.



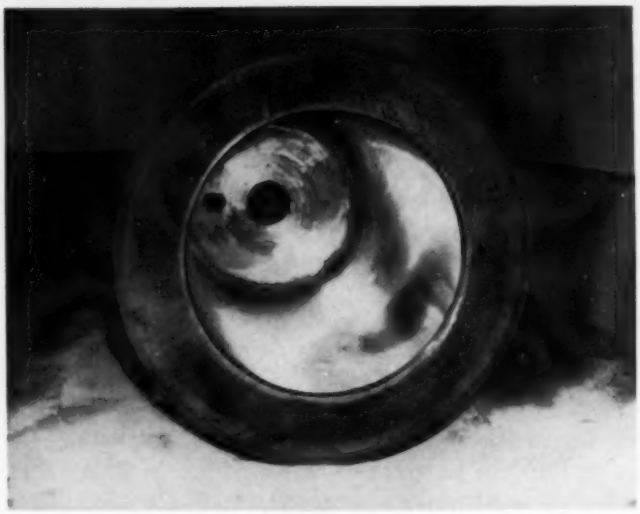


Figure 5 — Chromium plated cast steel main cylinder for a 1500-ton press, 34-in. inside diameter × 92-in. × 24,000 lb. Diameters which are off-size may be rebuilt by electroplating as an economical measure of salvage.

So far, we have concerned ourselves with production equipment exclusively, none of it in direct contact with the product itself. In the mills which might be classified as finishing units, product finish is the primary consideration. In this category are the cold reduction mills, particularly strip, and their coordinated operations such as pipe and tube mills, hot dipped tin, galvanizing and electrolytic tin lines as well as metal forming.

The use of chromium plating on the electrolytic tin lines presents many examples of how valuable it can be in controlling the quality of product finish. Starting with the cold reduction mills, the pull rolls, tension and coiler rolls are good applications. Here the hard chromium surface properly finished is capable of resistance to scuffing, scratching and mars which in turn, mark the sheet and reduce the quality of surface finish. The roller levelers including pinch rolls are also successfully chromium plated accomplishing the desired quality control and, at the same time, reducing maintenance servicing expense. On the tin line itself the conductor rolls in the cleaning line, plating line and special treatments are almost impossible to maintain in top operating condition without chromium plating.

The solid copper conductor rolls used in the acid electrolytic tin plating lines are maintained at constant diameter by rebuilding with copper plating in conjunction with chromium plating. This maintains the rolls at top strength and fatigue resistance together with efficient electrical conductivity and preserves the investment in an expensive article. Another advantage to be gained from maintaining constant diameters of all the rolls in the tin line, is reduction of sheet slippage, which not only affects the quality of tin plate but also wears the rolls faster and shortens the reconditioning and replacement cycle. The surface condition of all rolls in the tin line has a direct bearing on the quality of the finished product.

Auxiliary equipment in the tin mills also offers opportunity for reducing maintenance and replacement

expense by means of chromium plating, including again pumping and hydraulic units, sheet deflectors and many other parts subject to wear on a source of maintenance problems.

In the welded tube division, the skelp forming rolls, particularly for high quality light gauge tubing, offer less scuffing or marring of surface and increase of production when chromium plated. Turning again to hydraulic equipment, the pipe expansion and sizing units and the tube testing units offer the same general problems affecting maintenance of equipment and production with comparable benefits from chromium plating.

By now we have covered all of the production units and will turn for a moment to materials handling and transportation equipment. Crane axles have already been mentioned, hoisting equipment, diesel and steam engines and many other pieces of equipment have working parts subject to wear and replacement. Chromium plated cylinder liners in diesel locomotives are standard with some locomotive builders, and many railroads. Even older steam locomotives are using chromium plated piston rods, cross-head guides and valve rods with excellent results. An old Porter yard engine was equipped with chromium plated main piston rods in 1945, and in 1952 the same rods were in such excellent condition they were reinstalled without reworking. Needless to say, the rod packings performed in comparable fashion.

The description of successful chromium applications could continue, but it is hoped the coverage to this point has been sufficient to fan the imagination. It is time now to turn the discussion towards some of the practical problems affecting the planning and engineering of industrial chromium plating applications. Best results from chromium plating are undoubtedly obtained through close cooperation between plant engineering, production and metallurgical departments, with the plating service organization. Operations, maintenance and the plating organization have their peculiar and individual problems and all must be coordinated toward a common end.

Figure 6 — When packings are not easily accessible, the need for plated cylinders is accentuated. This is illustrated by the main actuator cylinders of a 2000-ton coning press. The block is a steel casting of 60,000 lb with the three main bores chromium plated 0.020-in. on the diameters. The center bore is 33¼-in. diameter × 43-in. and overall dimensions are 9-ft 6-in. × 8-ft 4-in. × 4-ft 10-in.

Of prime importance is a thorough knowledge of basis metals on which the chromium is to be applied. The plating engineer is often handicapped in the case of used parts because of a lack of definite knowledge or, at best, only general information is available. Under such conditions he must undertake the plating of such parts more or less on a trial and error basis, depending upon observations of the piece as submitted and drawing on past experience. On new or replacement parts, consultation between the plating engineer and plant engineering or metallurgical quality control affords an opportunity to specify the best basis material to meet requirements.

On the subject of basis metals, the plating engineer looks for density and uniformity of grain structure, freedom from segregations of impurities and relative hardness. The ideal would be the highest possible standards in any of the common materials such as steel forgings, rolled bar or plate stock, cast steel or cast iron and the alloys in all forms. This does not mean, however, that sub-standard materials are completely undesirable, because the experienced plater has developed ways to correct and overcome voids and inclusions frequently found in the lower grades of iron and steel; and on occasion even in the better grades. Porosity and small blowholes in castings, for example, can be filled before plating to provide a continuous plated surface when necessary. When desirable, a surface free of defects or mars in any form can be produced, virtually perfect.

A question frequently raised has to do with thickness specifications. The chromium deposit may vary from 0.0001-in. or less to as much as 0.025 to 0.030-in. or more, measured radially. Generally speaking the heavier deposits are reserved for salvage operations where it is desired to restore a badly worn surface to standard dimension. The extremely thin deposits are desired for light wearing operations, cutting tools, gauges or special applications where only thin deposits will meet the requirements. There are very few applications of this type in the iron and steel industry. On the majority of parts subject to wear and corrosion, deposits from 0.001-in. to 0.012-in. to 0.015-in. will suffice. Broadly speaking, an average thickness for good results within practical and economical limits would be between 0.005 and 0.010-in. Selection of the proper thickness for any given application should take into consideration the type of basis metal, heat treatment if any, condition of the metal, surface finish, operating characteristics of the equipment and the old standby—experience.

Finally, the user of chromium plating will be concerned with finishing. Generally speaking, the chromium deposit as produced will require finishing, although there are exceptions to this rule. Chromium is too hard to be worked with metal tools and it is, therefore, necessary to rely on abrasives applied in various ways. Where extreme accuracy or precision is not required, any degree of surface finish can be developed with abrasive coated polishing wheels or belts. It is desirable to develop a relatively high degree of finish on chromium plated parts. Because of its hardness and

lack of flow or peening qualities, chromium does not "break in" the same degree or sense as softer and more workable metals. When extreme accuracy is desired, the precision finishing machine can be used, such as grinders and hones. Any chromium plated part can be finished in such machines limited only by the capacity of the machines themselves. Large rolls, for example, up to 60-in diameter and 20-ft long have been precision ground after chromium plating.

One last word about finishes. It is possible to develop special purpose finishes of durable quality by means of chromium plating. One example of this is illustrated by the "open-grain" surface developed for diesel engine liners and other friction loaded surfaces where retention of lubricant is not only desirable but necessary to successful operation. The small surface pockets or depressions are deliberately induced by pre-treatment of the basis metal or a post-treatment of the chromium deposit. A second example of direct interest to the steel industry, specifically the electrolytic tin line, is the use of a fine nodular surface on current carrying rolls. This has been successful on the alkaline bath lines in particular, and provides two primary advantages, namely better pulling power or less slippage, and secondly less pickup of tin with the many disadvantages that result from such conditions.

In closing, a few remarks concerning where and when to use chromium plating might be appropriate. It is not wise to generalize too much on this subject as many opportunities for time and money saving applications can be overlooked. There are, however, sound rules to be observed. From the viewpoint of production and maintenance, there must exist first of all some degree of necessity for action. Chromium plating must also of necessity compete with other materials and methods, and comparisons should be fairly drawn within the limits of knowledge at hand. But chromium plating is a special service and trained and experienced consultation is available for an appraisal of any given problem. The rule to be observed is, therefore, to call on the plating engineer and the experience and special knowledge of chromium plating which are his to offer.

DISCUSSION

PRESENTED BY

S. S. JOHNSTON, Technical Director, Electrolytic Department, Weirton Steel Co., Weirton, W. Va.

H. F. JACQUART, Master Mechanic, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

JOHN B. ALLEN, Sales Manager, Chromium Corp. of America, Chicago, Ill.

DR. RICHARD WICK, Research Engineer, Bethlehem Steel Co., Bethlehem, Pa.

RALPH I. SWANSON, General Supervisor Research, United States Steel Corp., Gary, Ind.

HARRY DAY, Machine Shop Foreman, The National Supply Co., Ambridge, Pa.

EDWARD O. BARKLEY, Assistant Superintendent Mechanical Dept., Republic Steel Corp., Donner Plant, Buffalo, N. Y.

ROBERT A. KRAUS, Assistant Maintenance Superintendent, Republic Steel Corp., Chicago, Ill.

S. S. Johnston: From a maintenance standpoint, as this paper points out, there are many proven applications where a chromium plate over a moving part has reduced maintenance to a fabulous degree. This in turn has resulted in longer schedules of operating time with a sharp reduction in loss of production due to a breakdown during operations.

As the authors have suggested, there are many, many more places where chromium can be used to advantage. Some of these we know; others we do not know. Many are in that sort of "twilight zone" where the advantages of a chromium application may be offset by increased cost. At this time it becomes necessary that we re-evaluate some of these applications because inflation is catching up with us. Higher labor rates in turn mean higher maintenance costs. Sometimes we can spend more money on maintenance of a part than the part is worth and the application of chromium might reduce that maintenance cost almost to nothing.

The authors report failures of some applications of chromium and there are many other reports of failure from the field. Some of these failures are undoubtedly due to mis-application and many are also due to a faulty job of chromium plating. The past few years have seen great progress in the knowledge, technique and know-how of chromium plating. Past failures should be re-appraised to determine whether they were due to faulty work or poor judgment in application. If failure was due to inferior plating, the benefits of chromium plate may yet be realized by taking advantage of the technical advance in the modern technique of chromium plating.

H. F. Jacquart: Our experience at J&L has not been of the most successful type. There is every probability that perhaps it has not been successful because we have not been properly advised. This I am not prepared to say. We have been aware of chromium plating for shear plunger application and various hydraulic uses for possibly 8-10 years at our plant.

About 1946, we tried such an application on the 32-in. plunger of a 2000-ton hydraulic shear. Our normal wear on this plunger prior to this installation was approximately one year. As Mr. Allen pointed out, it meant that every year we were tearing down the shear to reline the housings and replace the bushing and plunger.

We installed a chromium plated plunger in this shear. For about six weeks it looked like it was a very successful application. About that time, the chrome plating started to flake off. It is possible that the heat in itself was too great for the plunger to have survived the chromium plating. It flaked very badly. We were forced to take a shutdown at a time when we could not afford one to replace the plunger. Naturally, we are now very cautious about the use of chromium plating.

We do however have several applications of chromium plating on pistons in some pumps. We find them very satisfactory. We have taken various different wearing parts out of certain types of valves in these pumps

and have chromium plated them successfully. In March of this year we installed a new 2500-ton hydraulic shear. About three weeks ago we noticed the same effects on this chromium plating as we had experienced on our previous installation about which I have just spoken. The manufacturer of this shear was very insistent on chromium plating and told of the very excellent results they had experienced to date. So we went along with them on this application.

I thought perhaps Mr. Allen could possibly give us some light on our particular problem.

John B. Allen: Mr. Jacquart does have a complaint involving and concerning the heat. Is there not a casting carrying the shear blade itself from the end of the ram?

H. F. Jacquart: Yes, about 52-in. in diameter.

John B. Allen: Does the flaking which has taken place occur within the working stroke of it?

H. F. Jacquart: No. It would be on a long stroke but it is in the portion of the piston that receives the least amount of surface contact and is closest to the heat. Of course, you have to reset your shears from time to time so that when the plating does flake off, and that portion is taken up into the cylinder, you immediately pull your packing back out with it.

John B. Allen: It does not seem as though the heat would do it unless there is an expansion of metal at that point; or the clearance in the bushing is not quite enough to take care of it. For example, I described in the paper the damage which took place to that 3000-ton shear plunger. I have forgotten what the clearances were in the bushing of that installation, but we decided that if anything like that happened again we were going to make some provision to take care of it as much as possible. We took the mouth of the bushing and belled it quite a bit so that the bearing surface, or the bearing surface load which took place there under those circumstances would be distributed over as large an area as possible. That was one thing we thought of. I am afraid I can not answer you any more than that.

H. F. Jacquart: I am thinking about the fact that the basic steel expands more rapidly than the chrome.

John B. Allen: The ratio is not quite one to two. In other words, yes, it would; although the existence of that is not harmful in itself.

Richard Wick: Bethlehem Steel Co. has developed, through plant service test procedures, many steel mill applications of chromium plating for engineering use. This was done over a period of years. Some of these applications have been described in the Proceedings of the Association of Iron and Steel Engineers. (1), (2). The authors of the present paper have contributed useful material on such chromium plating applications.

The reduction in repair and maintenance cost and downtime, and the extension of service life of wearing elements of machines, determine the usefulness of the chromium plating technique. To be effective the chromium plating must be fully adherent to the base metal to which it is applied; this is a circumstance that is not obtained by casual electroplating practice. The use of an adequate thickness of chromium plating is important. There are instances where 0.015 in. finished thickness of chromium gave good cost reduction in operation, while 0.006 in. thickness gave poor results.

The use of substandard materials referred to by the authors is to be avoided wherever possible for the severe service applications which usually characterize steel mill requirements, and also from a chromium plating cost standpoint. The use of such materials introduces a salvage operation before chromium plating. The hardness of the underlying steel otherwise necessary should not be reduced simply because chromium plating is specified. Besides the desirable mechanical properties of chromium that have been described, additional emphasis might be placed on the high degree of corrosion resistance imparted by the use of these chromium electrodeposits.

This pertinent paper reflects the continuing growth and interest in the engineering use of chromium plating in the steel industry.

Ralph I. Swanson: The paper just presented has been an interesting summary of the possible broad application of chromium plating in an integrated steel plant. Many of the applications mentioned have been successfully used at Gary Steel works.

Like any relatively new process, it is safe to say that there are probably a number of important applications of chromium plating on steel mill equipment that have not yet been developed. Judging by our own experience, the authors have not emphasized too strongly the value of chromium plating in hydraulic process and control equipment. While there have been a few failures, the experience at Gary Steel works has indicated that where difficulty is encountered in maintaining the packing on a rod, piston, or cylinder, usually chromium plating will help to solve the problem. The distinctive characteristics of chromium plating, namely, resistance to corrosion, hard abrasion resisting surface, and the low coefficient of friction, form a combination of properties that overcome many problems common to hydraulic systems.

While the properties of hard plated chromium suggest many application possibilities, one of the properties not so desirable is the relative brittleness of this material. Since the plating is thin and relies on the base metal for support, it would seem that a harder, less easily dented or scored base metal would give a more satisfactory chromium plated part. I wonder if the authors have any specific suggestions as to the use of a harder base metal which would give more support to the chromium plating.

John B. Allen: Yes. I mentioned that the plater must have certain qualities in the basic metal upon which he is going to apply the deposit, and one of the qualities I mentioned was hardness. Now, Mr. Swanson raised a point which has caused failures in chromium plating in some instances, but regardless of that it is amazing how much abuse the deposit can stand. We can point to installations where hydraulic rods, for example, or rams, have been quite badly grooved and sometimes dented during operations. Yet the plating has not cracked or broken off, or come off the surface. It has merely followed the deformation of the basis metal. It will not always do this, to be sure, because deformation

(1) "*Chromium Plating in Maintenance Practice*" by R. M. Wick, 1948 Proceedings AISE.

(2) "*Engineering Applications for Chromium Plating*," by R. M. Wick, 1952 Proceedings AISE.

can go to such an extent that the chromium deposit just simply cannot take it. It will take a certain amount, however. The ideal condition, of course, would be to have a relative degree of hardness under the chromium deposit. Take a rolling mill roll. We all know they have to be hard, very hard, or the surface will break down very fast.

In other industries we run into the same category. One might not think that finishing of paper could exert such pressures on a chilled iron roll of 75 to 85 scleroscope hardness as to cause denting, but it will. There the chrome plating has been very successful. The degree of denting, however, is relatively minor, and that is the point I think that we have to make. What are the conditions of operation? What are the hazards involved wherein an incident may arise that will exert terrific localized pressure and deform, flow, or dent the basis metal? When the hazard is great then I think the specification for the piece to be plated should include some form of surface hardening, or heat treatment other than nitriding.

Harry Day: I would like to know if 0.40-0.50 per cent carbon steel is a good base metal for chromium plating?

John B. Allen: Yes, it is.

Harry Day: How about 4130 SAE?

John B. Allen: 4130 and 4140 are also good basis metals.

Harry Day: What causes spalling?

John B. Allen: Overloading the surface is a very simple answer to that but not all-inclusive.

Harry Day: Could that be caused by undue pressures of packings?

John B. Allen: Not of the packing itself. Something might lodge in the packing, or excessive bearing pressure usually against the bushing.

Harry Day: Another thing that happens quite often is spalling of the plating and also the parent metal.

John B. Allen: Yes, that often happens. Naturally we point to that as evidence of the strength of bond which we actually accomplish in applying chromium.

Harry Day: In other words, you think that it is not caused by an improper bond between the plating and the base metal.

John B. Allen: When the base metal comes off with it, the way it often happens, we have often found under conditions where spalling has occurred, it is not only the chromium but the base metal, too.

Harry Day: That happens sometimes. We have in our plant a lot of hydraulic equipment. We have increased our life by the use of chrome plating, and on our pistons, rams, and so forth, as much as five to ten times the original life. Our packing life has increased, but we do have this spalling of the chrome plating and sometimes the spalling of the base metal also.

John B. Allen: Usually, however, you can boil it down to the simple statement that I made in the first place. There has been some localized overloading of the surface. In that case we can revert again to the last question, relative to hardness. That often will take care of it. In this particular case it would be more or less a form of emergency. Something has happened to overload the surface at that point. It might be something has gotten into the packing.

For example, in a case that actually happened on a large forging press cylinder on a 10,000-ton press, an unfortunate incident took place wherein the strainer from the main water line broke. There was a monel coil in that particular set-up that let go and the strainer broke up. The little pieces of metal went into the main cylinder. They lodged in the top of the ram in an upward stroke and just dug right into that wall. The steel casting collapsed. I have forgotten the exact analysis of it, but there just was not enough strength to transmit through the chromium wall resistance to gouging. It tore up the cylinder wall. We went in there and actually patched that area. We had to weld, polish, put on plating, seal the wall of the cylinder and fill in the damaged areas.

Harry Day: In this case of spalling, do you believe it is possible to make a repair to that particular part?

John B. Allen: If it is a big piece of equipment, it would be well worth while to do it.

Harry Day: I am speaking of rams, six, eight, ten inches in diameter. Could it be done there, too?

John B. Allen: Yes. In other words, it could be done thus saving the necessity of tearing down the piece. You have to balance off the estimated time in making repairs against the estimated time in replacing the unit. If it is a relatively simple unit, it could be replaced in a couple of hours. Then the repair is probably not desirable. If it is a big piece of equipment that takes hundreds of man-hours to tear down and put back up, it is probably worth while.

Harry Day: On a thrust bearing, on a 51-in. rotary type piercing mill, we have a diameter of about 20 in. We had it hard chrome plated to take the wear off the oil seals. That did not stand up at all.

John B. Allen: You have a terrific thrust load there.

Harry Day: Yes, but there is no thrust load on the spindle itself, that is on the oil seals. The load is on the spindle itself and the rotary effect of the spindle on the oil seals cut right through. It only lasted a couple of months. Lubrication was positive, and it was a high-grade alloy casting of 275 Brinnell.

John B. Allen: You would have to analyze that by studying the piece. If there are stresses of the basis metal indicated, that possibly could be the underlying cause there or it could have been possible lubrication failure.

Harry Day: We had 0.018-0.020 in. chrome on and it was ground surface.

John B. Allen: It could be lubrication failure. If the load is sufficient there, the lubrication may actually be squeezed out of the bearing surface; and incidentally, chromium does have poor wetting power from the standpoint of lubrication. That is why I mentioned the open-grain, or pitted type of surface in connection with heavily loaded bearing surfaces in order to retain as much lubricant in the bearing as possible. That is a possibility under heavy load.

Harry Day: This oil seal was of the garter spring type and there is a possibility of the garter spring being too snug.

Edward O. Barkley: In 1939 we chrome plated the rod bearings of two crank shafts for a 300-hp, 10 by 12 diesel engine. After about two months service we found that the chromium had spalled to an extent that necessitated removal of the crankshafts. Examination in-

dicated that the parent stock was unchanged, but that true spalling had taken place in the plating. Has your technique been developed to the point where you can handle cases of this kind successfully?

John B. Allen: Yes. I think so. By way of illustration, I will mention the standard test we use today in connection with the chrome plating of cast iron piston rings. Out of every plated load we select three rings, various locations on the order of those rings are tested by sledge hammer blows. If the chromium flies off, it is no good and the lot of rings is rejected and will be replated. Otherwise, the ring will break up and the chrome will stay right on every piece of iron that breaks off.

Edward O. Barkley: Are you actually plating crankshafts for large diesel engines?

John B. Allen: We have done them for some locomotives. We are going to do one shortly for a stationary; not the entire shaft, but one or two bearings. That is more or less a salvage operation. We have done some for diesels. I cannot be more specific than that.

Robert A. Kraus: We would be interested in knowing if you have had experience with the hard chrome plating of wire drawing blocks on draw benches, and has it been successful?

John B. Allen: Yes, particularly in the non-ferrous field.

Robert A. Kraus: We are, of course, not too interested in that field.

John B. Allen: Particularly there, but we have done work also in the ferrous field. It worked successfully in Chicago, not only on the wire drawing blocks, but also on wire flattening rolls. It is working very well there. Hardness is the desirable feature there, hardness underneath the chromium.

Robert A. Kraus: On a nickel-iron casting?

John B. Allen: Yes.

Member: On an application where you have a small hydraulic press, about 3 in. diameter, the plunger subject to water, will chrome plating the plunger help to prevent the plunger from rusting and prevent it from going back in the cylinder?

John B. Allen: Definitely.

Member: Would you chrome plate both the cylinder bore and the plunger?

John B. Allen: If it is a double-acting unit, the cylinder and plunger both.

Member: This is only a one-way hydraulic jack, and it moves the plunger out and it rolls them. In other words, it is a single-acting cylinder.

John B. Allen: Does the cylinder itself have no direct contact with the ram?

Member: We have about 0.003 in.

John B. Allen: I understand now, a typical jack installation.

Member: The plunger is 3 in.; the bore of the cylinder is about 0.003 in. over.

John B. Allen: I would recommend plating one only of the contacting or sliding surfaces. The other surface would be stainless steel, nickel alloy, or something to resist the corrosion.

Member: Another question, before you chrome plate it would it be better if the plunger was ground first?

John B. Allen: Yes, it should be ground. We prefer it, as I mentioned. The condition of the surface is an important factor in applying chromium. Generally speaking, we do not like tooled surfaces. The average tool used to machine steel or iron has a terrific pulling or tearing effect on the surface, and there is a weakening effect right at the joint, you might say, between the chromium deposit and the basis metal under those conditions. We do not like to see machine marks to the point where the surface is stressed and tearing takes place.

Member: Suppose in salvage the coupling were chrome plated, if you were to pull that coupling on and off periodically, would you lose your fit being chrome plated more so than you would otherwise?

John B. Allen: It is hard to forecast exactly what is going to happen. Years ago we were successful in chromium plating the male half of a two-piece crankshaft for Pratt-Whitney engines. They eventually eliminated that type of construction. The problem was freezing and crawling of the two surfaces when disassembling the crankshaft during a periodical overhaul on the engine.

We chromium plated the male member, and I do know that in that instance they could press out the male half, that is, separate the crankshaft, several times. That was the main purpose of the plating, but there are other factors you have to take into consideration.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

DEVELOPMENTS IN SUBMERGED MELT WELDING FOR STEEL PLANT MAINTENANCE

By D. E. KNIGHT
Development Engineer
Linde Air Products Co.
Division of Union Carbide and Carbon Corp.
Newark, N. J.

. . . . welding is particularly valuable in steel plant maintenance since savings in downtime may be more important than what is saved in reclaiming the equipment . . . .

▲ UNDER the severe operating conditions that exist in the steel mill, the wear and tear on equipment is terrific. Equipment is costly and the replacement of vital parts such as mill feed-rolls, backup rolls, and press columns adds thousands of dollars to the maintenance bill. Early methods of rebuilding worn surfaces, even for the few jobs to which they were applicable, were usually so laborious, time consuming, and expensive that they were of questionable value except in emergencies.

In recent years the use of submerged melt welding has made it possible to reclaim worn steel plant equipment quickly and economically. By this method, metal of extraordinary soundness is deposited rapidly with unusual uniformity, and at costs lower than for any other method.

Resurfacing applications are usually mechanically controlled so that successive weld beads will neatly overlap to produce a uniform smooth bright surface, free from defects, either on the surface or below it. In every way, the deposit has become an integral part of the original piece. Such surface deposits may not only restore the reclaimed piece to its original dimensions, but may be made of metals with special qualities to give even better performance than the original material. Submerged melt welded surfacing is uniform, wears evenly, and has a long service life. The deposit is smooth and clean and for many services requires no machining or finishing. When finishing is required, the welded deposit machines the same as forged material of similar composition.

Since a considerable proportion of the repair work in steel mills is done on cylindrical surfaces, the relationship between the diameter of the piece and the welding current or speed are important factors to consider in preparing for the repair of these parts. These values may be readily determined by using the graph shown in Figure 1. The dotted curve gives values of diameter versus current. The solid-line curve gives values of diameter versus welding speed.

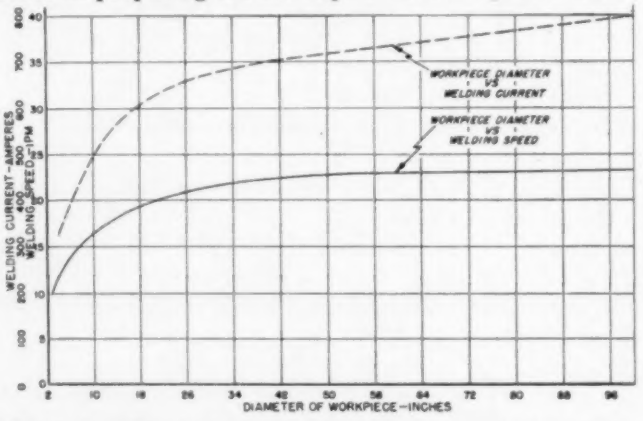


Figure 1 — Graph shows relation between workpiece diameter and welding current and speed.

In submerged melt welding the welding takes place beneath a cover of granulated non-metallic mineral welding composition. This presents another factor that must be considered—the problem of maintaining a

proper amount of welding composition over the weld zone, when such things as rolls and crane wheels having curved surfaces are being rebuilt. Flat or cylindrical surfaces of over 8-in. radius seldom require any retaining devices. However, such devices must be used on smaller curved or sloping surfaces and also for welding to the edge of a flat surface. A wire brush makes an excellent retainer for curved work. The bristles rest against the work and support the composition while welding lasted four times as long without showing appreciable wear. New wheels cost $240 but the cost of rebuilding by submerged melt welding was $40 each, with a resultant saving of $200 per wheel.

At another plant heavier crane wheels are rebuilt at a cost of $100 each. When new, one of these wheels cost $680. Since this plant uses 50 wheels per year, the management was well impressed with the saving of $29,000 on this item alone.

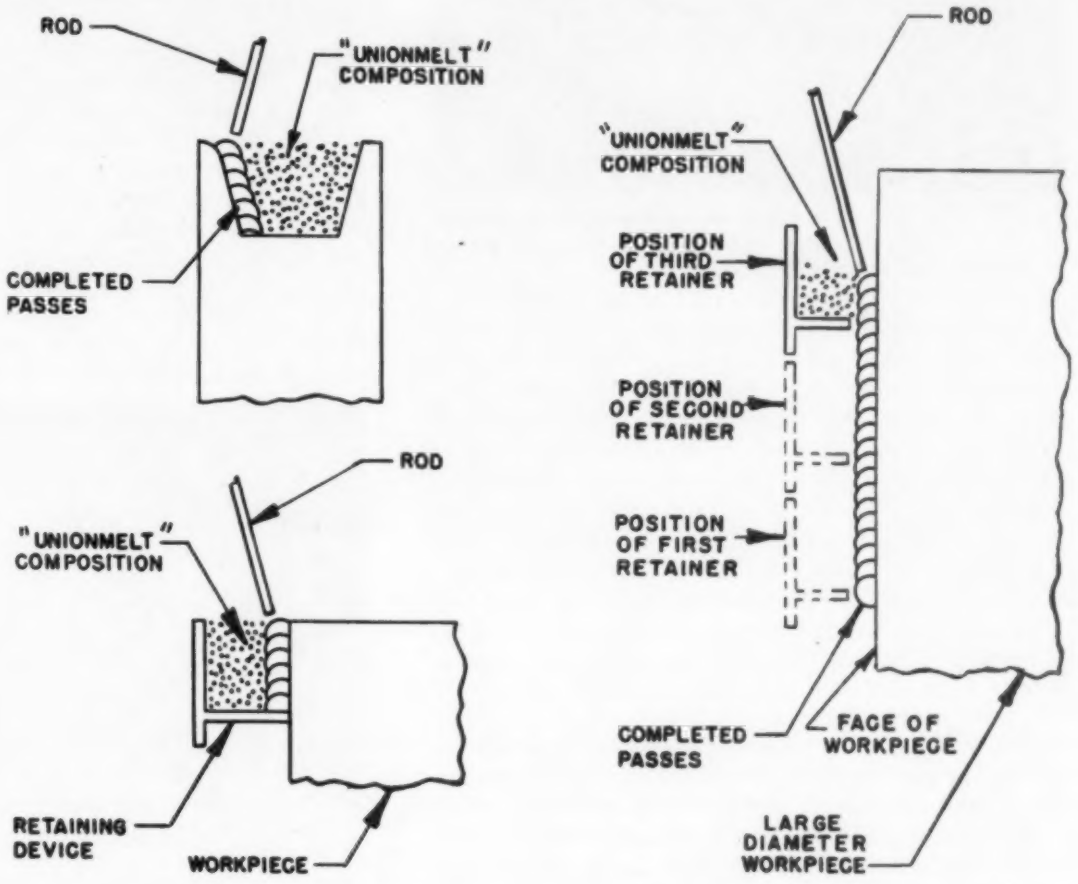


Figure 2 — Retainers hold composition for making welds on vertical surfaces.

the brush still has the flexibility needed to accommodate uneven surfaces and previously deposited metal.

Figure 2 shows how retainers are used also for applying welding beads to a vertical surface. Usually these retainers are made of sheet metal and are clamped or tacked to the outside of the work. If the vertical surface is large, it is helpful to use retainers of progressively larger size as the work progresses.

A helical overlapping bead is generally used in surfacing cylindrical objects. Within limits, the thickness of each layer is controlled by the transverse movement of the rod. The more overlap, the greater is the thickness produced. Best results are obtained when the part is mounted in a machine providing controlled traverse, such as an engine lathe with the welding head mounted on the tool post. In many plants it is regular practice to rebuild crane wheels and locomotive wheels this way. As an example, at one plant, a 21-in. diam wheel with a 4-in. face was mounted in a lathe and rebuilt in 2¾ hours with 25 lb of metal. When wheels like this were rebuilt by manual arc welding it took 12 to 16 hours per wheel and the rebuilt wheels lasted only 3½ months. A new set of wheels rebuilt by submerged melt

A larger example of similar work was the use of the process to rebuild kiln tires. These tires were 13 ft in diameter and 12-in. wide. By rotating the kiln in its normal position, a light cut was taken over the face of the tire to provide a clean, smooth surface. Each trunnion was next machined down ¼-in. deep over half of its face and the welding deposit was then made on this half of the tire. The other half of the trunnions were then cut down and the deposit made on the remaining part of the tire. In this way, the weld was made without disturbing the alignment of the kiln or disassembling the tire.

A mill table roll which had been badly gouged was about to be scrapped when it was decided to try to rebuild it with submerged melt welding. After the roll was preheated, the welding deposit was made without any further preparation. In eight hours, the operator deposited 105 lb of metal on the roll and increased its diameter by $\frac{7}{16}$-in. No finish machining or lathe work was required and the roll was returned to service in the as-welded condition. Total cost of build-up was $49.58, while a new roll would have cost $285.

A worn mill feed-roll, 13-in. diam, was rebuilt in 29

Figure 3 — A furnace was constructed around the bed of the lathe to pre-heat and maintain temperature on the roll while being welded.

hours including preheating. The roll was preheated between 300 and 400 F and rebuilding was completed in two passes. The finished weld was so smooth that very little machining was required. Subsequently, rebuilt rolls were not machined at all but were placed in operation in the as-welded condition. New rolls cost $1400 and the worn ones are rebuilt for about $140 so that savings on this job amounted to about $1250 per roll.

A cast steel backup roll for a hot strip mill was recently rebuilt by submerged melt welding when the roll, 54-in. long, had been worn down from 49 to 47-in. in diam. See Figures 3, 4, and 5. Analysis of the casting showed that the main alloying elements were: carbon, 0.94 per cent, chromium, 0.88 per cent, and molybdenum, 0.39 per cent. It was determined that similar physical properties could be obtained from the deposit of a carbon, chromium, molybdenum rod. With metal of this composition, the welding engineers considered it desirable to weld at a temperature which would prevent transformation and retempering of the deposit by subsequent passes. To do this, it was necessary to preheat to between 800 and 900 F and maintain this level during the entire time required for resurfacing. The

Figure 4 — Roll was rebuilt from 46 in. to 49 in. in diameter.

roll was carefully prepared for welding by magnetic flux inspection and was turned down from the 47-in. worn diam to slightly over 46-in. to remove surface cracks. After preheating, the roll was transferred to a welding lathe and the temperature maintained by a furnace constructed around and above the bed of the lathe. Several pairs of gas burners placed symmetrically beneath the roll supplied the necessary heat. With burners adjusted individually, the temperature of the roll could be closely controlled. Thermocouples were welded to each end of the roll body and connected by slip rings and brush contacts to a recording pyrometer. In addition, temperature-indicating crayons and a contact pyrometer were used frequently along the surface of the roll body and weld deposit. By using these indicators, temperature of the roll was kept between 825 and 925 F at all times.

The roll was rebuilt from 46 to 49-in. in diam. Welding current was 550 amp and speed was 20 ipm. By moving the carriage $\frac{1}{3}$-in. for each revolution the beads were applied overlapping each other and making a layer $\frac{1}{8}$-in. thick. After the welding was completed, the roll was held at 900 F for 12 hours and then cooled

Figure 5 — Beads were applied overlapping each other making a layer $\frac{1}{8}$ in. thick.

slowly to 250 F. Again, it was heated to 1050 F and held for yet another 12 hours, and then furnace cooled to 250 F. Initial cooling from 900 F produced a uniform transformation of the weld deposit while the subsequent reheating to 1050 F and cooling tempered the deposit to the desired hardness range of Rockwell-C 38-40. After heat-treating, the roll body was ground to size. Inspection by magnetic flux tests proved that the deposited metal was completely sound. Performance of this roll led the plant management to rebuild another roll with higher surface hardness, designed to improve service life.

The reclaiming of shafts is just as important as roll-rebuilding and it can be quite as rewarding. When the bearing end of a pinion drive-shaft 26-in. in diam snapped off through metal fatigue, it was decided to repair the part by machining a new end and welding it to the pinion by submerged melt welding. Both parts were machined to form a bevelled joint and drilled to take a 4-in. plug. The whole assembly was pinned together with the plug and aligned in a large press, while reinforcing bars were tack-welded across the joint. After the parts were preheated to 700 F, the joint was submerged melt welded and then machined. About 275 lb of rod was used to make the weld. Figure 6 shows the

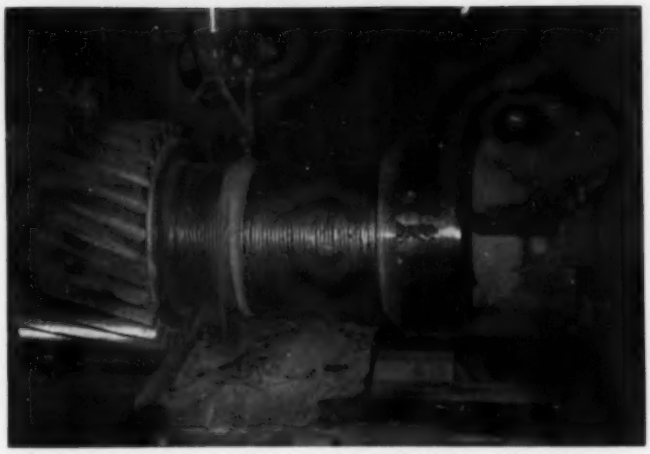


Figure 6 — Broken pinion shaft, 26 in. in diameter was repaired by submerged melt welding.

joint completed and a single helical pass made over the entire bearing length.

In the same way, the process is used to repair broken roll necks. At another large steel plant, this type of work had been done by another welding process. Consequently, when submerged melt welding was introduced, costs were watched closely. In both operations, labor for machining the parts preparatory to welding was the same, but with submerged melt welding, the cost was about 12 per cent less.

In another plant, four columns for a 1000-ton press had been scrapped because of wear. Submerged melt

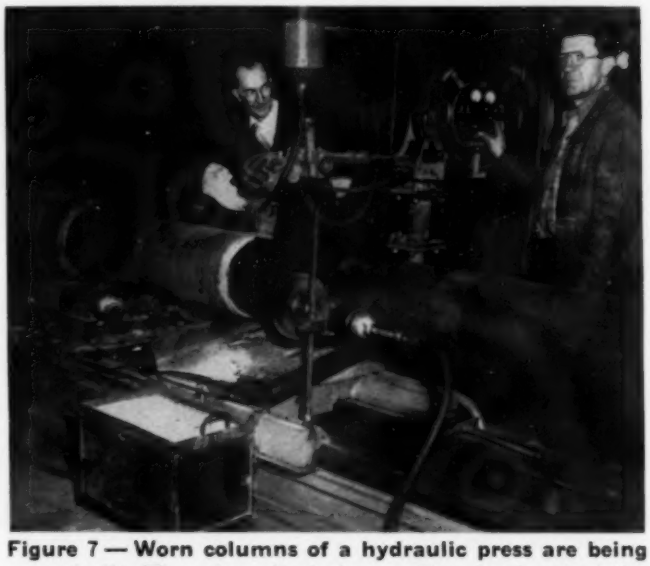


Figure 7 — Worn columns of a hydraulic press are being rebuilt. The wire wheel cleans off scale ahead of the welding zone.

welding was used to rebuild these columns, 20-ft long and 11-in. in diam, and return them to service as good as new. An oxyacetylene preheating head and a motor driven brush were mounted on the carriage of the lathe ahead of the welding head, and after the shafts were preheated to 500 F, the welding was done at a speed of 16-rpm. The wire brush removed all soot, scale, and rust from the shaft just before welding as shown in Figure 7. To rebuild each column the operator deposited from 145 to 190 lb of material. The average cost was $167 per column whereas the cost of a new column is $2370. Thus, savings of $8000 resulted from this job alone.

A large Eastern mill has rebuilt a similar 1000-ton and also a 2500-ton press with proportional savings. For the larger press not only the columns, but the cylinder, pistons, nuts, or virtually the entire press was reclaimed. The threaded portion of the column and nuts were rebuilt with a chromium-vanadium type rod. The balance of the rebuilding was done using a low carbon rod, manganese steel rod and a 0.65 per cent carbon steel rod.

Workpieces as small as 1⅞-in. in diam have been surfaced by submerged melt welding. For such work, the spindle or shaft is placed in a lathe as shown in Figure 8. Weld metal is deposited in an open helix using a triple-lead cross feed on the welding head. After

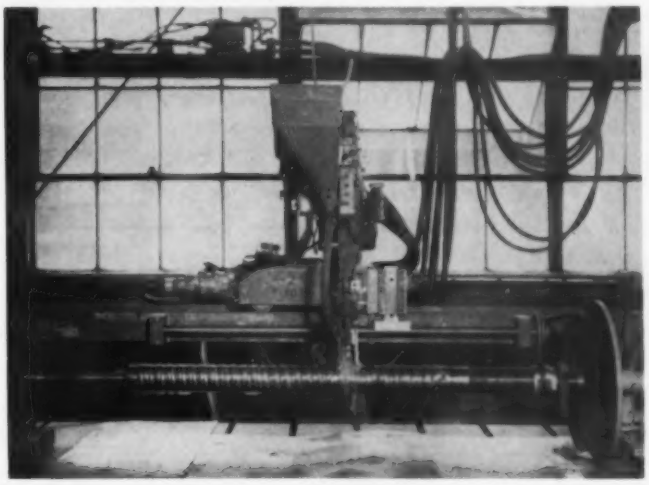


Figure 8 — A small-diameter shaft is rebuilt by depositing three open spirals of weld metal which overlap to form a complete cover.

the first pass is completed for the entire length of the workpiece, the welding head is then repositioned at the original starting point and advanced a distance equal to one-third of the helix pitch. Similarly, after the second pass has been completed, the head is returned and positioned for the third pass. When completed, the three overlapping beads form one complete layer of surfacing deposit. And the surface of the spindle is smooth and will require only light machining to return it to its original dimensions.

Although difficult to do by other processes, inside surfaces are rebuilt quite easily by submerged melt

Figure 9 — The worn bore of a ram is being rebuilt through a 6-in. diam opening.

welding. With the equipment shown in Figure 9, the bore of a hammer ram was decreased by ½-in. The ram was welded into slots cut in two circular rings, 30-in in diam and placed on turning rolls. Then the welding head was mounted on a standard machine carriage and was equipped with a 24-in. extension nozzle. Welds were made in a longitudinal direction at a speed of 8 ipm. After each bead, the ram was rotated a half turn and, because the bore was tapered, a second layer was deposited on top of the first over the larger half of the bore. The ram was stress relieved, machined and returned to service. Welding and preheating the ram took about 11 hours, however, it would have been practically impossible to repair the part using any other welding process.

Conical pieces are resurfaced by mounting the part with the axis in an inclined position and the part attached to a turning positioner. A track is supported above or beside the work so the welding head can be positioned after each revolution of the piece. This type

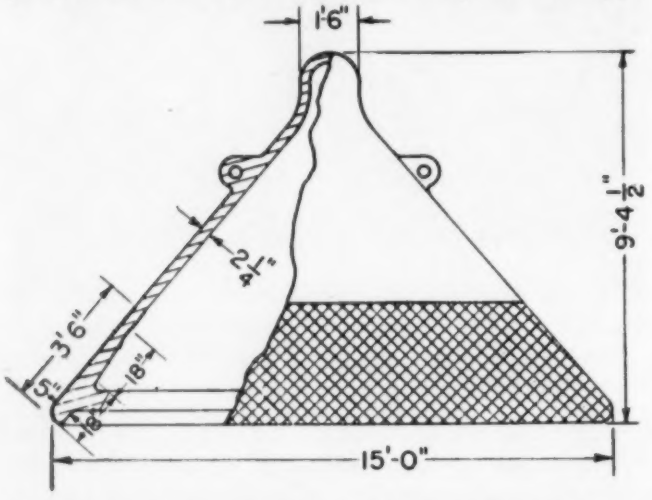


Figure 10 — The lower surface of a blast furnace bell is rebuilt for a distance of 3½ ft to replace metal lost by wear.

of installation is used for applying metal to the worn edges of a blast furnace bell. The portion of the bell over which metal is deposited is shown in the drawing, Figure 10. The same type of installation is used to resurface crusher cones, mantles, and winding cones.

In addition to the wide use of the process for cylindrical surfaces, it is used on flat pieces as well. After one pass is deposited, the machine is returned to the starting point and the head moved transversely one half the width of a pass before the next pass is made. The surface is thus covered with a series of overlapped passes making one layer of deposited metal. To carry the deposit out to the edge of the piece, retainer plates are necessary to support the welding composition.

Welding heads are often equipped with extensions to enable them to reach undercut surfaces such as occur in the reclaiming of a worn cross head guide. The equipment shown in Figure 11 consists of a regular type U-head mounted on a mechanized carriage and equipped with a curved nozzle. An adjustable guide has been added to the end of the nozzle to position it accurately and thus control the overlap of each deposited bead. Similarly, the process is used on other flat parts like

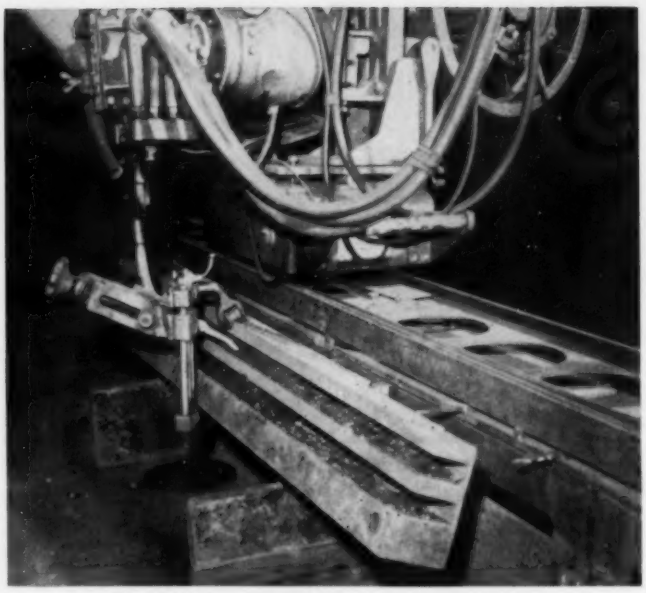


Figure 11 — Worn surfaces of a locomotive cross-head guide are rebuilt by submerged melt welding.

back-up chucks, unloading chutes, conveyer wear-strips, coke pushers and mill guides.

The flexible welding equipment which was introduced a few years ago has made it possible to do submerged melt welding in narrow and confined spaces. Also, this apparatus is particularly useful where a number of short or irregularly shaped welds are required that cannot be done economically with the fully mechanized equipment. Flexible welders have the advantage of using high current up to 700 or 800 amp, with corresponding high rate of metal deposit to produce welds that are smooth, dense, and free from slag or flux. The portability of the equipment and the ease

Figure 12 — Damaged slag pot is repaired with portable flexible welder.

Figure 13 — Blade of alligator scrap shear is cracked completely through.

with which the 17-ft flexible hose can be taken directly to the work area have combined to make this an excellent tool for repair and maintenance of all kinds of equipment.

The portability of the equipment is shown in Figure 12 by the way in which it has been taken into the yard to repair eroded areas in slag pots. Defective metal is first removed by oxygen gouging or cutting. The welding nozzle is guided by hand and the gouged place is filled in with clean, sound, weld metal. In this illustration, a portion of the pot was cut out and a piece of plate fitted into the opening. The deep joints were quickly welded using the flexible welder.

In one large plant, the blade of an alligator shear cracked in service and was repaired with a flexible attachment connected to a standard type D-head. The

Figure 14 — The shear blade was welded on both sides with the flexible welder and is ready for service.

cast steel blade cracked straight across from the throat to the top of the blade as shown in Figure 13. After the blade was removed, the crack was veed out and the parts lined up and tack-welded. The assembly was then preheated to 700 F and covered with asbestos paper to shield the worker and to conserve the preheat. The operator deposited 200 lb of metal to repair the blade which was welded from both sides. The completed blade is shown in Figure 14. It was estimated that a saving of $250 was realized over other conventional methods of repair.

Another example of the usefullness of this equipment is in the rebuilding of wobbler pads. After all low spots and worn areas are built to within $\frac{3}{16}$-in. of size, areas are finished to size by applying a hard-facing rod. The rebuilt areas are shown in Figure 15. Welding starts at the end of the wobbler and progresses inward. The next pass overlaps the first and is made in the same direction. In this way, the deposit is built up until it is the desired size.

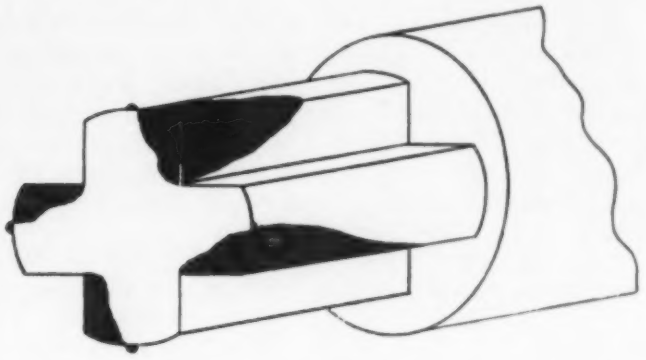
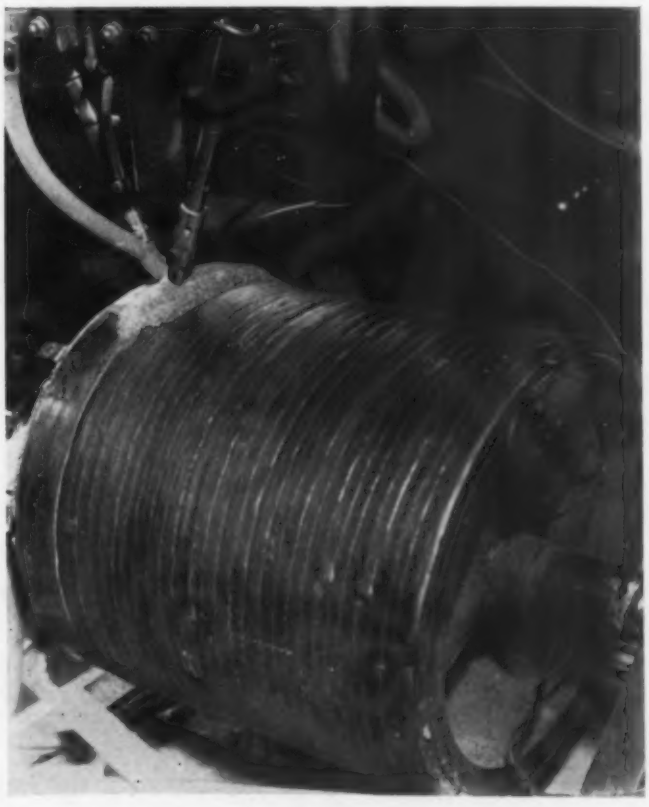


Figure 15 — Wobbler pads are easily rebuilt with the flexible welder.

There are two developments in welding technique that may lead to new uses and wider application of submerged melt welding. These are tandem welding and series welding. In tandem welding, two welding heads which are electrically independent operate one behind the other. The advantages of two-pass welding are obtained in a single pass of the equipment; welding speed is increased and welds can be made in thin sections

Figure 16 — Clad hollow roll has stainless steel applied by series arc welding.



that could not support a single-pass weld of the equivalent size.

Series arc welding also uses two welding heads, but they operate in series. That is, the current passes from one electrode through the weld puddle to the other. The advantage of series arc welding is that heat is produced by the flow of current from one electrode to the other and therefore relatively little heat is generated in the workpiece. Thus, a minimum of base metal is fused into the weld puddle.

An example of series arc welding is shown in Figure 16 in which a coating of stainless steel is being applied to a hollow roll made of mild steel. The two heads operate side by side and a-c power is used. In ordinary submerged melt welding, as high as 60 to 70 per cent base metal is usually present in the weld metal. Using the series arc technique, as little as 10 per cent of the base metal is mixed into the weld puddle.

Since its introduction, submerged melt welding has been useful for the steel production as well as steel fabricating industries. Increased costs and the pressure of present day operation make it necessary to seek ways of doing things better and quicker. Where it can be applied, submerged melt welding fully meets these requirements by making the highest quality welds, at extremely high speeds, with mechanical precision. The flexible welder is particularly useful in making welds that cannot be mechanized readily. With the introduction of tandem welding and series arc welding, new fields of application are opening up. Cladding and hardfacing are developing quite rapidly. Almost certainly, these applications will give us ways of building and repairing our tools of production so they will last longer. Often, rebuilding parts returns them to service months before replacements can be delivered. Frequently, in addition to the savings in the cost of the equipment, greater savings are realized through the time that is saved. In the years ahead, submerged melt welding will be even more useful for the maintenance and repair, as well as for the production, of steel plant equipment.

DISCUSSION

PRESENTED BY

J. A. DRGON, Assistant Maintenance Superintendent, United States Steel Corp., Irvin Works, Dravosburg, Pa.

MICHAEL V. HERASIMCHUK, Chief Experimental Engineer, Bethlehem Steel Co., Bethlehem, Pa.

J. A. Drgon: Submerged arc welding is a process which is virtually indispensable in the repair and reclamation of equipment, and has been used by us for about seven years. New developments and increased experience in the use of this method of welding has enabled us to salvage and repair equipment at a considerable reduction in costs. Building up surfaces of back-up roll chucks, table rolls, spindles and internal surfaces, such as bores of work roll chucks is a common occurrence at our plant.

Michael V. Herasimchuk: The application of the submerged arc welding as discussed by Mr. Knight has obviously been a great help to many maintenance men. In fact, maintenance men are relying more and more on welding operations to salvage worn parts and to assure themselves that spare parts are always on hand.

The salvaging of equipiment by submerged arc or manual welding is sound practice up to a point. The dividing point is that instance when reclamation welding is used by persons who are unfamiliar with the parent metal or by those who may not fully comprehend the consequences of welding on parts where bending or alternating stresses are transmitted, or in areas where moderate stress concentration exists.

The indiscriminate use of submerged arc welding in such cases has given some maintenance people a false sense of security. For example, I recall the reclamation of the journal of a large pinion shaft about 9 in. in diam, about 12 ft long. After several years of service, the journal had worn sufficiently to rule out other methods of restoring the size, so the shaft was welded. It was welded from the end of the journal to the fillet, where the welding stopped.

A few weeks after returning to service, the shaft broke in the fillet. The cause was stress concentration in the tiny pits at the end of the weld in the fillet.

The lesson to be learned here is that it was not the submerged arc welding that was at fault; it was the indiscriminate use by the persons unfamiliar with the consequences of overlooking stress concentration factors associated with the fillet.

Before welding on critical equipment, it is advisable to consult, first, the welding supervisor; next, the metallurgist; and, third, the design engineers. The combination of the three talents should give satisfactory performance of equipment reclaimed by submerged arc welding.

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Plant Welding Applications

By H. J. RALSTON
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West Homestead District Works
United States Steel Corp.
Munhall, Pa.

. . . . welding has been a boon to the steel plant maintenance man . . . .

▲ IN discussing the subject, "Plant Welding Applications," it is with the realization that most men are well aware of the ever growing scope of welding in design, manufacture, repair, alteration and expansion of producing facilities. When considering the amount and variety of equipment and structures comprising an integrated steel plant, it will be readily appreciated that there are literally many hundreds of types of items which, for one reason or another require the application of welding for the most effective furtherance of these endeavors.

The types of services being performed with the assistance of welding would include simple fabrication, repair of fractures and surfacing either to prevent or replace loss of metal from erosion or corrosion. The types of metals used range from mild steel through moderately alloyed compositions to the hard facing alloys, including austenitic manganese types, stainless types and cast iron. For the most part the processes being employed are manual and automatic arc, acetylene and thermit welding.

Today's accelerated production rates stimulated by the heavy demand for product have, of course, tended to emphasize the importance of all phases of welding. Some of the more obvious services are those being contributed by the field welders in the various producing units, particularly by their assistance in reducing outage time. In the rebuilding of open hearth furnaces, for example, replacement or repair of all or portions of damaged structures, water cooled elements and piping is hastened by welding.

Quicker restoration of operations in the rolling mills after an equipment failure is frequently made possible by the welder either as an expediency or as a permanent repair. Examples of typical difficulties remedied in this fashion would include: the slippage of gears, couplings and keys on shafting, the failure of the internal portions of flexible couplings, the fracture of brackets, lugs and other appurtenances projecting from more massive members and the anchoring of elements normally secured by bolts when replacements in kind are, by comparison, excessively time consuming.

One of the most pronounced increases in activity in type of welding in recent years is the application of automatic equipment to build-up work, particularly in the reclamation of worn machinery items. Much of this equipment operates under adverse conditions of lubrication and temperature, and in some instances, under impingement by mill scale propelled by high pressure water sprays.

The average item removed from service because of wear is relatively expensive and is discarded reluctantly. By utilizing the high deposition rates and other advantages of submerged arc automatic equipment, worthwhile savings are being realized in the rehabilitation of such items for further service. Another advantage of an installation for such application is that it provides the maintenance man a means of rapid acquisition of a protective spare, an important consideration especially in view of today's extended deliveries on new equipment.

The majority of worn items being rehabilitated in this manner are rotating members and are cylindrical in shape. The installations adapting automatic equipment for this purpose have usually been improvised by plant personnel, frequently using discarded or otherwise obsolete items that have been made available. Most often, an old machine lathe has been the basis of the installation as it combines the necessary support and the desired rotational and transverse motions required for the operation. Essentially the operation involves the deposition of successive layers of continuous metal by rotating the work beneath the electrode, and by simultaneously advancing the electrode along the work at a suitably slow rate to effect an overlapping of adjacent beads.

Figure 1 shows an installation built around a 63-in. diam engine lathe. The automatic d-c controlled head utilizes the output of three, paralleled 400-amp, a-c driven, d-c output machines. The wire feed motor circuit is interlocked with the lathe drive motor to provide, if desired, simultaneous starting and stopping of welding and rotation of the work. Finely incremented speed regulation over a suitably wide range is provided by rheostat control of the lathe motor driving through one of four basic ratios in the lathe gearing. Rotation is clock-wise viewed from the tail stock.

A splined column, mounted on the swivel tool post base, supports a vertically movable arm carrying the automatic head, flux hopper and electrical control panel. The electrode reel and a vacuum separator and storage tank are mounted on the top of the column. Makeup flux is added to the tank from the platform above and is discharged after an interval into the hopper. The excess unfused flux falling from the rotating work is directed by a chute into an air stream returning it to the same tank. The pump and motor for the vacuum system is mounted on the lathe carriage.

Thermally induced variations in the length of the work are absorbed by a 10,000-lb railroad type compression spring in the tail stock housing between the lathe center and the rear of the housing. Spring compression, in 1000-lb increments, is registered by a pointer and gauge at the rear of the housing. The heavier items are supported by bronze carrier bearings.

Additional features include a pneumatic hammer mounted to insure fused flux removal from the ascending bead, a long bristled flexible wire brush also mounted on the ascending side near the apex of the work to assist in supporting the flux, and appropriate perforated gas pipe manifolds for preheating and maintaining temperatures as required.

Figure 1 — This old engine lathe has been used as a basis for applying welding to circular sections.

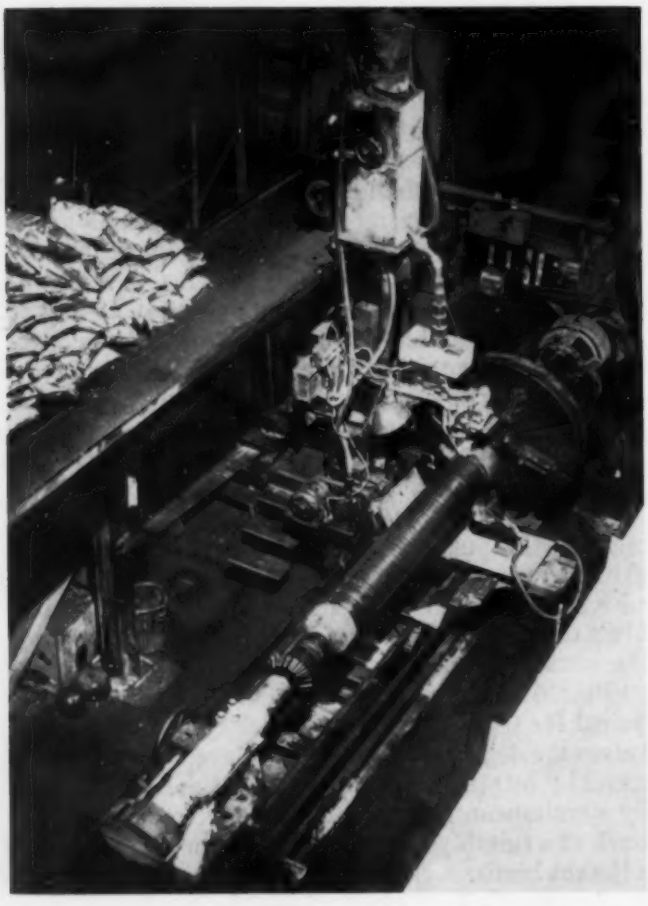

Figure 2 — Attachments to the welding set include a pneumatic hammer, wire brush, and gas pipe for preheating purposes.

Figure 2 is a close-up of the welding of a roll journal showing the arrangement of the last three mentioned items. Whenever required, the temperature of the roll may be raised by lighting the gas for an interval without necessarily interrupting the welding.

Figure 3 — It is advisable to protect the welding equipment from the heat caused by the work.

Figure 3 is a close-up of the assembly of some of the equipment showing the welding of a structural blooming mill shape roll. The rectangular composition board and perforated steel pipe carrying compressed air around the head serve to protect the head motor and gear case from the excessive heat of the work.

Figure 4 is another view of the same roll. In this instance an unused but obsolete roll was salvaged by building up certain select surfaces as much as seven inches in diameter. The asbestos rope acted as a support for the flux at the vertical edge of the ascending beads.

Figure 5, showing an oscillating head shear eccentric, illustrates another method used in supporting the flux at a run-out, namely, the use of sheet metal bands, temporarily butted and tacked to the end of the object.

Another advantage of build up work is apparent in Figure 6. All the expense of dismantling and reassembling as well as the cost of a new shaft has been eliminated by welding the undersized portion of the shaft at the right end to provide a proper fit for the nicking lathe headstock necessary to complete the assembly.

Figure 7 illustrates another type of repair possible with the welding installation. The heads of the open hearth charging machine peels had broken off in service. A machined plug and socket fit at a reduced diameter section, together with a suitable "V" when fitted together provide an assembly that could be welded by rotation.

For most efficient operation, it is necessary that the various controls, amperage, voltage, polarity, rotational speed, position of electrode with respect to the apex of the work, temperature of the work and the effective pitch of the carriage screw be coordinated to utilize the highest practical deposition rate and to produce a bead of proper contour. The most desirable bead is one that is relatively flat and wide with a slightly convex surface tapering off gradually at the sides to meet the adjacent metal smoothly. The pitch usually selected is such that about one-half of each bead is refused in the formation of the next succeeding one. The overall surface so produced is relatively free from valleys, notches between fusion zones and craters and is the most economical from the standpoint of necessary stock removal in machining. More important, the absence of sharp depressions with their stress concentrative tendencies reduces crack development potential. High beads with abrupt undercut edges favor slag inclusion in the deposit and interfere with smoothness of operation by making slag removal difficult.

Deposition rates are limited by the diameter of the work. With objects of large diameter (about three feet and over) the full output of the generators may be utilized. As progressively smaller diameters are contemplated, amperage must be reduced and the other controls critically adjusted to prevent spillage of flux, slag and metal over one or the other side of the apex of the work. This is particularly true in the positioning of the electrode which is carried slightly ahead of the apex on the ascending side. Excessive heating of the work adds to the difficulties by delaying the hardening of the slag. Objects with diameters much less than six inches and inside surfaces of cylinders are generally considered too troublesome for this submerged process. A coated electrode fed by an appropriate automatic head is much more satisfactory for work of this type in that the flux supporting problem is eliminated and the slag layer chills more rapidly because of its relative thinness and its direct exposure to the atmosphere.

In Figure 8 an automatic setup of this type is shown in operation building up the inside surface of a roller bearing cartridge. The coiled coated electrode is mounted on a large reel (not visible in the photograph) and is propelled by rubber coated wheels through the spring loaded contacts to the surface of the work. A welding positioner is here used to revolve the cartridge. The cross feed table on the welding head supporting carriage provides the operator with the necessary lateral adjustment to insure a smooth continuous bead. Tubular goose neck attachments are available for guiding

Figure 4 — Roll is being built up by welding.

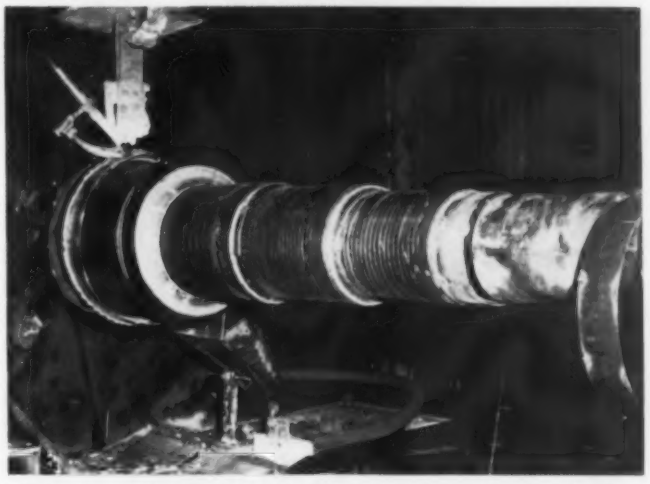

Figure 5 — Sheet metal bands are used to support the flux at a run-out.

Figure 6 — In welding repairs, much of the dismantling expense may be eliminated.

Figure 7 — Heads of charging machine peels were rebuilt by welding.

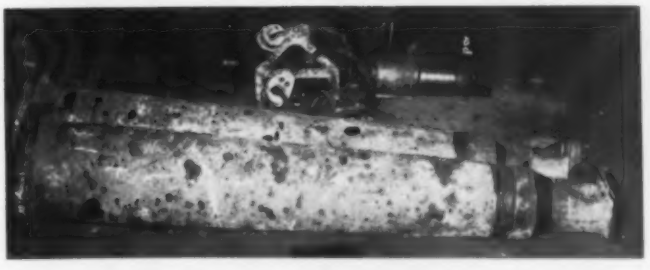

Figure 8 — Automatic set-up shown was designed to weld on inside diameter.

the electrode into less accessible areas, as for example, into a cylinder having a relatively long bore of small diameter.

In this automatic process, electrical connection between the contacts of the head assembly and the core of the electrode is provided by fine spiral wires wound directly on a specially shaped core and the coating thickness so regulated that portions of these wires are exposed. In cross section, the core is shaped somewhat like a cross to provide recesses for the inclusion of sufficient coating for adequate pool coverage.

Automatic welding submerged and otherwise is, of course, also being used for building up flat surfaces. In this instance, the work usually remains stationary while the electrode is moved along the desired path by a motorized carriage supporting the head. Portable outfits are quite useful and represent a minimum of investment.

Figure 9 shows a more elaborate gantry crane installation designed not only for this work but for general fabrication as well. Motorized controls provide three adjustments to facilitate positioning: lateral movement of the crane, vertical movement of the head and rotation of the carriage beam track. The item being welded is a blooming mill bearing carriage. Temporary plates have been tacked to the edges to support the flux and provide a run-out. Visible, to the rear, is another item set up ready for welding.

In selecting items for rehabilitation by automatic build-up it is well to preserve a questioning attitude to assure the economic soundness of each venture. With certain items the advantages of the application are obvious and tremendous; with others it may be necessary to investigate costs and to consider this and other factors to determine whether reclamation is feasible. An item in the former category is the rolling mill spindle shown in Figure 10.

Mill spindles such as this are removed from time to time for reconditioning. In this instance, a new universal head is to be installed on the right end of the shaft, the shaft having been welded to provide stock for machining the proper fit. The other two welded areas are support bearing surfaces that had become worn in service. Occasionally reconditioning includes the manual welding of the internal curved surfaces of the heads so that they may be brought back to standard dimensions.

In certain instances, the advisability of salvaging items such as the table roller shown in Figure 1 is questionable because of the relatively large amount of electrode consumed. Frequently portions of the body are reduced several inches in diameter before removal from service so that upward of a thousand pounds of deposit may be required to restore an item to its original size. Each item must be considered individually.

In evaluating the benefits of buildup work, it is necessary to consider the serviceability of the reconditioned item, hence, usually the wear resistance of the deposit.

In contemplating the use of harder, more wear resistance deposits there are several factors to be considered:

1. Stress effects.
2. Available types of electrodes and fluxes and their relative costs.
3. Machinability.

Within reasonable limits, the additional cost of machining, occasioned by the harder deposits will be readily offset by increased service life, particularly in view of the relatively small amount of stock removal required for finishing items.

A reasonably comprehensive array of electrodes of various carbon contents with and without alloy combinations have been made available for submerged arc buildup work. Their characteristics and suggested applications of each type have been publicized in various

Figure 9 — Gantry crane installation was designed for general fabrication work.

Figure 10 — The advantages of welding items such as this rolling mill spindle are great.

advertising literature. The potential hardness range of available deposits independent of the influence of base metal dilution is from about 150 to 550 Brinnell.

Several types of flux are also available for specific purposes and have been designed not only for the primary function, deoxidation, but also for secondary effects such as optimum slag viscosity and for the introduction of regulated quantities of hardenable elements to the molten pool.

Highly alloyed electrodes may cost several times as much as the simple carbon varieties. Whether the anticipated additional serviceability can absorb the increase in electrode cost is sometimes debatable. The relative amount of electrode required to condition a given item and the nature of service frequently dictates the selection.

Stress is a most important consideration in the regulation of multiple pass buildup work. Still vivid is the memory of an early experience in the experimental welding of a 45-in. diam cast alloy steel roll—the witnessing of a progressive unfolding of a 1½-in. layer of deposit from the original roll surface. In this instance, the conditions of welding, although controlled, were not adequate to prevent the formation of a crack in the deposit. The crack may have originated from a flaw at, or just below, the original roll surface.

In most of the work it must be assumed that cracks in the deposits are too risky to be tolerated in that they may be propagated by service loading to the extent that costly failure results. In critical applications, even though actual visible cracking is not anticipated, it is well to consider the implication of high residual stresses in formulating procedures.

It is common knowledge that the higher hardness deposits are in general the ones more prone to crack. Other things being equal, this may be considered a reflection of the relative tendency of a metal of given composition to acquire rigidity in cooling through a range of temperature just above that of the object being welded. The following generalized observations are useful as a guide when considering procedures. They involve a consideration, for simplicity of presentation, of the initial cooling to room temperature of a single girth bead around a solid cylinder of appreciable diameter.

1. In this instance, as distinguishable from many other welding applications, no mechanical relief is afforded by slight displacement nor by deflection of members.
2. Stress development from simple thermal contraction tendency ceases when the bead temperature drops to that of the cylinder. In cooling to room temperature, temporary additional stress will develop if the bead and the surface cools appreciably faster than the center.
3. In cooling from this equilibrium temperature to room temperature an additional stress may result from transformation depending upon composition and cooling rates throughout the cycle. Furthermore, the capacity of the metal to accommodate any stress may be affected by the nature of the transformation product.
4. The higher the preheat temperature, the lower the residual stress, because of the narrowing of the range of temperature of stress inception. Also, the higher the temperature, the lower the hardness value because of the retarding influence of the heated mass upon the rate of quench and other allied effects of increased time at elevated temperature.
5. The maximum benefits of preheating to a predetermined temperature will be realized only if the cylinder is heated uniformly throughout; otherwise it will not be expanded to its maximum circumference.
6. Cracks in the surface of the base metal such as heat checks or spalls will almost certainly propagate through the weld bead during cooling unless they are sufficiently shallow to be eliminated by fusion. Removal by machining is usually advisable.
7. Sub-critical post heating may be employed to control residual contractional stress. The degree of removal and the corresponding reduction in hardness will depend primarily upon the maximum temperature selected.
8. From a stress standpoint this method of developing hardness in a hardenable alloy is at a decided disadvantage when compared to usual heat treating methods wherein the entire mass is heated to a hardening temperature and quenched. The fact is that in a quenching heat treatment, a favorable compressive stress may be developed at the surface rather than an undesirable tensional stress as the result of a contractional pull of the interior in continued cooling after the surface is rigidly fixed.

These observations indicate that there are practical limitations to be considered in the regulation of deposit hardness and that for maximum benefits, electrode selection and welding procedure should be considered with reference to the application. For example, a one or two pass deposit with a hardness value upward of 500 Brinell may be safely used on the surface of certain types of rollers, but possibly could not be recommended for the load carrying journal of such rollers. Experience must be used as a guide for optimum results.

One of the more popular electrodes being used for general buildup work today is an SAE 6150 composition employing about a 600 F preheat. Usually a maximum of 100 F drop in work temperature during welding is allowable followed by a post heating of 600 F or slightly higher. The hardness of the surface thus produced will compare favorably with the original straight carbon machinery grade represented by the item.

Preheating and post heating in rotational work may be conducted in the lathe using, if desired for increased efficiency, temporary encasements constructed of asbestos boards suitably supported. This is an excellent method of applying heat uniformly, rapidly and selectively to the surface of an object, but has the disadvantage of reducing available welding time. A pit type oven, 35 x 8 x 6 ft deep, located in the shop is used for preheating and postheating most of the items reconditioned with the equipment here shown.

Ordinarily the method of preheating of work is not particularly critical. However, in the heating of the larger masses of metal such as cast mill rolls, care must be exercised to insure uniform heat distribution over the entire surface; otherwise the object may be fractured as a consequence of unequal expansional tendencies. Heating rates, based upon surface temperature determinations, are sometimes restricted to as little as 10 to 15 degrees F rise per hour.

Bead composition is determined by the proportion of electrode to base metal contributing to its formation and by their respective analyses. The quantity of each element in a given pool is the sum total of that contained in the fused electrode and base metal modified by a certain loss of oxidizable elements, and possibly by an increase in alloyable metals, notably manganese and silicon, depending primarily upon the preponderance of these elements combined in a given flux. In multiple pass deposits, the effect of the composition of the original base metal diminishes, as the result of electrode dilution, with each successive pass so that an approximately constant composition is obtained after about the fourth pass.

If a selected electrode composition is at considerable

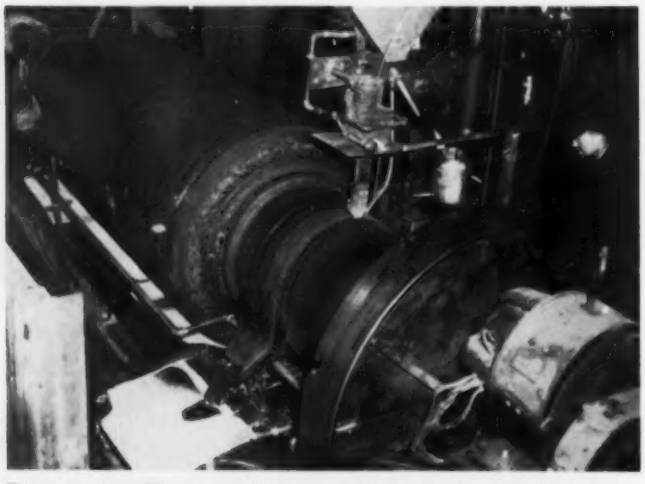

Figure 11 — This is only one of 12 cast alloy steel back-up rolls which was reconditioned by welding.

variance with that of the item, one or two "buffer" passes of unalloyed electrode are advisable to prevent unnecessarily high hardenability in this zone.

The cast alloy steel back-up roll in Figure 11 was one of twelve reconditioned for service in a 100-in. semi-continuous plate mill. Over a period of time, the journals had become worn as much as ⅛ in. in diameter by slight differential movement between the journal surfaces and the inner races of supporting roller bearing assemblies. The approximate composition of this group was:

C	Mn	Si	Cr	Mo
0.80	0.65	0.30	0.85	0.40

Preheating and post heating temperatures were 600 and 700 F respectively. Temperature was held close to 600 F during the entire welding operation using the gas pipe manifold fitted around the roll contour.

Two passes were used to insure a continuous machined surface. Electrode selection was influenced by the realization that the service loading of these areas is frequently severe and that a failure would result in a costly wreck. Anticipating an increase in carbon and alloy content from the base metal, a relatively soft (0.10C, 0.55Mn, 0.22Si, and 0.50Mo) electrode was used.

Some time ago a few rolls of this general type were reclaimed on an experimental basis by various plants using as much as 14,000 lb of alloy electrode on a single

Figure 12 — After welding, it may be desirable to case harden the welded structure.

roll to restore body diameter to its original size. Unfortunately, it was usually found that service life after reclamation was insufficient to justify the expense of the particular venture.

Figure 12, a 40-in. diam by 7-ft slabbing mill hydraulic up cut shear plunger is of interest in that it exemplifies the possibility of heat treatment after welding to obtain special properties. As shown, it has been reconditioned by a ¼-in. layer of deposit, followed by machining, grinding, pack carburizing at 1700 F, water quenching and tempering to give a case hardness of 62 Rockwell C equivalent, and a case depth of approximately ⅛ in. Final grinding to size is all that remains for installation. The electrode used was the same molybdenum bearing type used on the back-up roll journals. The base metal had a similar composition except that it contained an additional 10.15 per cent vanadium.

On rare occasions, an item for which there is no available replacement will become broken through a massive section as the result of some mishap in service. When this happens, the thermit process may be of inestimable value in facilitating restoration of operations. Aside from the urgency of a situation, there are, from time to time, quite a number of items that are profitably repaired by this method.

The preparation of a large thermit pour is an adapta-

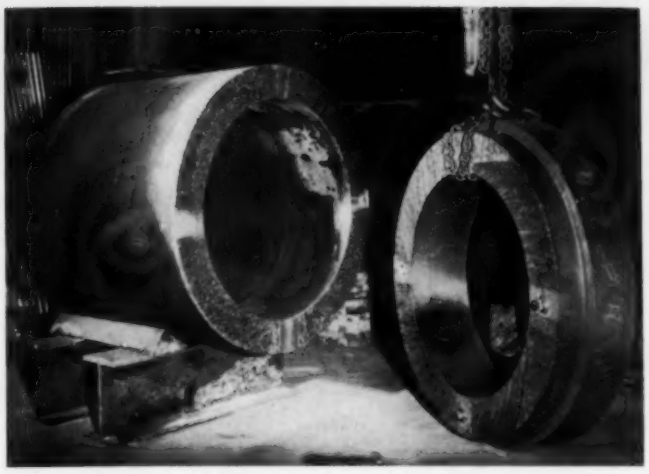

Figure 13 — A piece of equipment such as this may best be repaired by thermit welding.

Figure 14 — Wax was used as a temporary filler in preparing the weld.

tion of foundry moulding practice in channeling and containing the molten thermit in an aperture between the two surfaces to be joined.

Figure 13 shows one of four hydraulic press cylinders whose failure had caused a unit to shut down. The portion at the right is a replacement forging which has been machined oversized to permit final alignment machining after welding. The end of the main body also had been machined to provide a flat geometric surface for welding alignment. Each of the machined surfaces were scarfed with an oxy-acetylene torch except for four small equally spaced aligning areas. Scarfing is recommended to improve fusibility.

The four dowel pins projecting from the surface of the new section act as separators in establishing the gap to receive the molten thermit. In this instance, they also serve to support the new section as they were manually welded to the old, after positioning. The gap width, 1¾ in. was obtained from an established schedule based upon section size.

Wax is used as a temporary filler to exclude moulding sand from the gap in preparing the pour. In this instance the wax was heated slightly so that it could be worked into the aperture by hand and shaped as shown in Figure 14. Later, during preheating, it drained off through the bottom gate.

After moulding has been completed the sections are preheated as shown in Figure 15. It is customary to first heat the surfaces projecting from the mould boxes. This favors slow and uniform drying of the sand. Later after the sand has "set," carbon oil blast burners are used to bring the surfaces at the gap to about 1800 F. The flame is introduced through each of several heating gates such as the one visible at the lower right of the mould box. After preheating is completed, these gates are sealed with short steel plugs backed up by more rammed sand.

In Figure 16 the thermit containing crucibles have been positioned over the mould and the thermit ignited. After the reaction subsides, the crucibles will be tapped simultaneously and the pour completed. The mould will not be removed until the weld has cooled to within an estimated two or three hundred degrees of room temperature. After stripping, feeders and risers are removed by flame cutting prior to machining.

The importance of the field welders' contribution to sustained operations was mentioned earlier. A mill repair within the last year provides an example of this type of activity.

After an extended period of continuous production with only short weekly interruptions to make planned minor repairs, it became advisable to suspend rolling operations long enough for major repairs to certain equipment associated with the 45-in. slabbing mill shown in Figure 17.

Analysis of the work required showed that, with the exception of one item, outage time could be held to 72

Figure 15 — Sections were preheated in the mould illustrated.

Figure 16 — View shows thermit immediately after ignition.

hours. Reconditioning of this item, an element of the vertical mill, would have required possibly two weeks and a large expenditure of man power by usual methods.

The vertical rolls of this mill are moved horizontally in opposition as required according to the width of the manipulated ingot. The two reduction gear cases at the top of the mill on either side of the flexible coupling move simultaneously along horizontal splined shafts. The cases, equipped with bronze liners as sliding surfaces, are supported by two large separator castings spanning the top of the mill. The track surfaces of the castings had become worn in a dished fashion as much as $\frac{3}{8}$ in. It was suspected that this unevenness was adversely affecting other equipment in the drive. Coupling failures, for example, had been experienced.

The conventional method of restoring these surfaces would be to remove the castings for machining to accommodate liners. In view of the magnitude of this undertaking, it was decided to restore the worn surfaces by welding in place. The approximate dimension of each of the four areas was 7 x 100 in.

The cases were removed and eight welders worked simultaneously using straight edges to check flatness and elevation in finishing. Next, a heavy duty portable grinder was suspended from the crane and manually manipulated to improve the flatness of the deposit. Final grinding was done with hand cup grinders and checked with straight edges and squares.

The electrode selected gave a deposit hardness comparable to that of the original soft castings. A hard electrode was considered inadvisable because of the initial limited area of contact between the hand ground surfaces and the sliding bronze counterparts. The softer deposit could be expected to "wear in" sooner with a minimum of abrasion to the liners.

Figure 17 — Worn surfaces on this equipment were restored by welding in place.

All of this work was completed and the cases replaced ready for operation in the alloted 72-hr period.

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SAFE HANDLING OF FUELS, HAZARDOUS GASES AND LIQUIDS

By F. R. PULLEN
Fuel Engineer
Bethlehem Steel Co.
Johnstown, Pa.

. . . . observance of safe operating procedures facilitates production . . . .

A LIQUID and gaseous fuels and other hazardous gases and liquids can be handled safely when the work is planned, supervised and executed by properly trained men. Observance of safe operating procedures facilitates production. To ignore safe procedures invites delays, disaster and destruction.

The planning necessary to develop safe operating procedures rests with a plant's operating, engineering, fire, safety and service departments. The hazards involved in each step of any given operation must be carefully analyzed by these organizations long before the process goes into operation. The particular hazard or hazards may dictate the location selected for the equipment, the materials of construction used, and the particular safety devices needed. For example, liquid or gaseous fuels are stored in tanks above or below ground level outside of and away from buildings. The distance to the nearest building is determined by the capacity of the tank. Liquid fuel stored above ground should be protected by a dike of a capacity greater than that of the tank. Storage of volatile chemicals or chemicals with boil-over characteristics, like that of crude petroleum, may require similar safeguarding. In some cases, where it may be necessary to store hazardous materials inside buildings, a minimum quantity should be kept in a batching tank. This tank, of course, should be adequately protected from all hazards.

The chemical composition of the liquid or gas to be stored will dictate the materials of construction. Carbon steel plates are suitable in most cases. However, special cases may require stainless steel, ceramic linings, wood, lead or other materials. In each case only first quality materials should be used, since deviations from this standard invites future material losses through leaks, and, what is more important, imposes additional hazards on workmen and plant property.

The design of safety devices for adequate protection of the operation is a joint responsibility of the operating, fire, safety and engineering departments. This activity, as essential as the operation itself, is too often delayed until the project is in operation. This is a foolhardy policy to say the least. There are probably more hazards involved in the initial operation of a unit than at any other time. For this reason alone, safety controls and devices should be ready to operate as soon as the unit is started. A detailed study of the operation, which is necessary in the development of adequate safety devices, may bring to light a hazard which can be eliminated by improved planning in the original project, thus doing away with the need for safety devices. The maintenance or service departments should also study the problem from the maintenance point of view. Provision for emergency shut-off valves (remotely controlled if necessary), flooding valves, purging connections, access platforms, man holes, and similar devices should also be included in the original installation. Failure to include them may considerably complicate a relatively simple maintenance job in the future.

It should be kept in mind that it is easier, more practical, and less costly to provide for loss prevention when projects are in the design and engineering stage than when they are in actual operation.

A complete set of recommendations for the storage, handling and use of flammable liquids is found in the

National Board of Underwriters Pamphlet No. 30, 1952 edition, copies of which are obtainable from Underwriters Laboratories, Inc.

The second phase of a program for safe handling of hazardous liquids and gases deals with the training of employees and supervisors whose duties may expose them to such hazards.

A plant educational program must be developed, maintained and carried out on a regular, permanent basis. Such a program should include technical education and instruction as well as scheduled training and practice in the use of approved protective equipment and in artificial respiration. It must be designed to provide maximum plant coverage and to give every man the general knowledge required to protect himself and his fellow workers against the hazards from exposure to toxic, flammable, and chemically active gases or liquids.

In addition, each man must receive on-the-job training in the proper working procedures for his job under the guidance of his foreman or supervisor. A plant-wide training program will of necessity develop a safety code or set of accepted rules and regulations. Once such a code is developed, it is essential that all work, whether operation, maintenance or new construction, shall be performed in accordance with the principles and instructions contained therein. Detailed written job procedures must be developed and used in all cases where a written work-plan can contribute to the orderly and safe performance of the job.

Job safety analysis must be considered a part of each job and every man should assist in the development of possible improvements to existing techniques and practices.

Frequent safety inspections are a vital portion of any plant safety program. As previously pointed out, proper design, physical condition, and location of equipment are fundamental to the safe handling of hazardous gases and liquids. Equally important, however, is a regularly planned and scheduled safety inspection program. This should not replace the general routine inspection and maintenance plan now in use in each plant but is intended to supplement such a program. It is suggested that the safety inspection be carried out on an annual basis and should include the following steps:

1. Inspect and report on the physical condition of all fuel and other hazardous gas and liquid handling and distribution systems, including safety devices, controls, escape ways, etc.
2. Make recommendations for elimination of physical hazards.
3. Promote education of personnel in safe methods of handling and use of fuels and other hazardous gases and liquids.
4. Follow to completion all approved recommendations.

A brief review of the more prevalent hazards to be encountered in the production and use of toxic, flammable and chemically active gases and liquids is in order.

The most prevalent and most dangerous gas encountered in a steel plant is carbon monoxide. This gas is present in large amounts in blast furnace gas, coke oven gas and producer gas and is generally present in varying quantities in the exhaust gases from these and other fuels. It is occasionally found in sewer gas. It is well known for its toxic and explosive properties. Because of the many possible sources of this gas, especially around the blast furnace and coke oven sections, the proper maintenance of fuel systems, good combustion practices and adequate ventilation are imperative. It is also well to remember that these rules apply equally well to our homes and garages as to the plant.

Hydrocarbon compounds are another source of considerable hazards. This group includes many of the coke plant by-products such as coke oven gas, benzol and other light oils, napthalene, tar, pitch, carbon bisulphide, hydrogen cyanide. Other items in this category are petroleum gases and oils, gasoline, solvents, paint and sewer gas.

Most of the liquids and solid materials in this class are harmful to the eyes and skin when contacted. The vapors of these materials are generally toxic when breathed, even in minute quantities, and are also highly explosive. The Bureau of Mines Bulletin No. 503 "Limits of Flammability of Gases and Vapors," lists the limits for the simple gases and many combinations thereof as well as many of the liquids encountered in steel plant operations. Copies are available from the Department of Interior, Washington, D. C. at a nominal charge.

Because of the hazardous properties of all of these materials, it is obvious that only trained personnel should deal with them. Their use in the home should be avoided.

All compressed gases, with the exception of oxygen, will produce a suffocation or asphyxiation hazard if allowed to escape and displace the air in a confined area. Storage and use in confined areas therefore must be prohibited. Cylinders should be stored in a dry cool place, not exposed to direct sunlight or to vibration which may cause them to be upset. It should also be remembered that the fracture of the valve connection on a cylinder by bumping or by the use of an oversize wrench can convert the cylinder into a dangerous projectile. A case is on record where an oxygen cylinder with a broken valve passed through an eight-inch brick wall.

Union threads on gas cylinders as well as pressure reducing valves are made different to exclude indiscriminate interchange of these parts and to prevent the use of a fitting unsuited either because of pressure or chemical activity.

Cylinder gas fittings, other than the conventional types, should only be used after instructions have been obtained from an experienced gas or combustion engineer. If an experienced engineer is not available, study should be made of "Matheson Gas Data Book," second edition, 1951, which contains complete descriptions of cylinder gases and data on thread types, size and material of construction of connections and reducing valves.

No gas cylinder should be used if there is any doubt about its identity or the operator's ability to handle it. The proper respect for and careful handling of cylinder gases is essential to the safety of the operating personnel.

Steel plant operations require the use of many chem-

icals. Specific methods of handling are necessary for the welfare of those who work with them. Specially developed safety wearing apparel and protective equipment must be kept available for every type of work. Plant equipment used in such operations should be inspected frequently and carefully, and should always be kept in good condition.

As a service to chemical consumers, the Manufacturing Chemists Association, Inc., 246 Woodward Building, Washington 5, D. C., has published a wide range of handling and storage bulletins, safety data sheets and like material. These bulletins are available on request. The general Chemical Division, Allied Chemical & Dye Corp., 12 South Twelfth St., Philadelphia 7, Pa. has the following special manuals available without cost.

"Unloading Rubber-Lined Tank Cars"
ICC. Class 103-B
"Unloading Nitric Acid From Tank Cars"
ICC. Class 103-C & 103-C-A1
"Unloading Steel Tank Cars"
ICC. Class 103-A
"Unloading Non-Regulatory Liquid Chemicals"
ICC. Class 103 & 108

Generally speaking, all of these chemicals are very corrosive in liquid form and their vapors hazardous. First aid treatment in all cases consists of flushing affected area with water for a period of at least 15 minutes and obtaining medical attention quickly.

Contact of acids with metals may generate hydrogen in sufficient quantities to create an explosion hazard. For this reason, open flames or spark producing equipment must be avoided around or near storage or point of use. Contact with wood, wood shavings, excelsior or other organic materials may produce toxic fumes.

Construction and maintenance work on fuel and hazardous liquid and gas systems can be carried out safely if all factors relating to safety are observed. The following conditions must be provided to insure safe procedure:

1. Only trained and competent supervisors should be assigned to the job.
2. Complete job planning must be worked out, with step-by-step work procedures for all men and departments involved in the job. No detail should be overlooked and all responsibilities properly assigned.
3. Provision must be made for all safety protective equipment, testing equipment, and tools. It must be assumed that trained workmen and competent supervisors are available. If not, time must be taken to train a sufficient number to handle the particular job involved.

A series of meetings should be held in which the job is fully investigated and discussed, with all the principles involved. A definite procedure should be developed and written up, detailing the various steps, with estimated time required, starting with the preliminary preparations and continuing through to the final clean-up. The write-up should include the assignment of responsibilities for each portion of the preliminary work, the actual job, and the clean-up. A final group meeting should be held to adopt the procedure developed, after which the working procedures and assignments adopted shoud be carried out unchanged. Emergency conditions may arise which may make it necessary to modify the planned working procedures. In such an event, an on-the-spot meeting between all departments involved should be held and an agreement reached before the job is allowed to proceed. In all cases, each step should be carried through to completion before the next one is started.

The detailed job write-up should list all protective and detection equipment for the job in question, along with the person or department responsible for furnishing it. Trained stand-by personnel such as firemen should be on hand, and safety belts, stretchers and similar materials required should be available.

In the event that the job deals with a flammable gas or liquid, it will be necessary to purge the system prior to the start of maintenance work. Purging must be carried out after the system has been isolated and must be carried through to completion before work is again resumed. If the system contains solids or liquids which may evolve toxic or explosive vapors, or in the event oxy-acetylene burning or welding torches are used, it is necessary to continue purging while maintenance work is being carried out. Where personnel must enter the system, the inert purge medium must be replaced with air using a forced-ventilation fan to supply fresh, clean air. Purging upon completion of the job must be carried out to insure the safe return to normal service.

The most desirable purging mediums are considered to be:

1. Inert flue gas generated from the products of combustion. This should be cooled and washed prior to use.
2. Carbon dioxide.
3. Nitrogen.

Steam is not included, since the physical characteristics of steam prevents its general use as a purging medium. It should never be used for purging large systems or long lines where thermal expansion will create a problem. The need for maintaining a flow of steam throughout the job also makes working conditions miserable to say the least. The physical characteristics of water also prevents its use as a purging medium.

Prior to the start of a job, all tools and equipment should be inspected by a responsible person to eliminate any unsafe or unsatisfactory appliances. Work in hazardous gaseous atmospheres require the use of spark-proof tools, explosion-proof lights and power tools. All safety and rescue equipment should be inspected and be in readiness should the occasion arise.

Where it becomes necessary to make repairs to tanks or other systems containing acids, alkalis, or hydrocarbons, the problem of sludge disposal presents itself. As much of the sludge as possible should be removed from the outside of the tank, using long handled hoes, water jets or other methods. The remainder must be removed manually from the inside. In this case the tank or vessel should be opened, ventilation established, the material on the walls neutralized and washed down with hoses. When this has been completed, the atmosphere should be tested and, if safe, men permitted to enter. Each man should be equipped with a safety belt and a life line and backed up with adequate

stand-by forces equipped with suitable gas masks outside the tank or vessel. Upon completion of the work, the necessary precautions shall be taken in returning the system to service.

Certain maintenance jobs such as painting, minor external repairs, etc., can be accomplished without interrupting the operation, if it is adequately planned by the departments and crafts involved, and adequately supervised. Departmental safety rules as well as those pertaining to the particular type of material handled must be followed in all cases. No repairs should be permitted on moving equipment, where electrical hazards exist, or where any other conditions may make the operation unsafe.

To conclude, it is possible to construct, operate and maintain fuel and other hazardous liquid and gas systems if certain rules are followed. While each case differs somewhat, the following steps may be considered typical.

1. Adequate engineering prior to construction, including shut-off facilities, purging points, vents, drains, etc.
2. Plan the job in detail and prepare a written job procedure to be followed.
3. Obtain management's approval.
4. Obtain and deliver to the work site all necessary tools, safety equipment, first aid equipment and gas or vapor detection equipment.
5. Provide positive isolation of the system or lines involved in the work to be done, blank off inlet and outlet connections, and remove or blank off all other connections.
6. Purge with an inert medium to a safe concentration. Repurge with air (forced ventilation) if employees must enter system.
7. Shut-off or regulate purging operation according to purged gas tests in system and proceed with maintenance work. Continue periodic check of atmosphere in system or, preferably, install one or more continuous recording or indicating instruments and analyze the atmosphere.
8. Upon completion of maintenance work, repurge with inert gas, then replace with normal material by bleeding purge out. When checks show a normal material analysis, the blanks may be removed and the system returned to normal service.
9. The maintenance department shall assign the force necessary to clean-up and return to the operating department in line with good housekeeping practices.

Remember that the observance of safe operation procedures facilitates production; to ignore them invites delays and destruction.

DISCUSSION

PRESENTED BY

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F. Bruce Bevelheimer: As an additional source of information, the Industrial Commission of Ohio has put out a code on the transmission of oxygen in pipe lines, and the use of fuel gases with oxygen in the various machines that use that type of equipment. I am thinking particularly of the flame arcing device. They had a very serious accident in 1951 that brought about this desire for a code for everyone to live up to. It might be well for some of the people to apply for that. I have a copy of it while it is not complete, it is quite excellent.

V. B. Garrison: The difficulty of writing a paper on, and of administering, a program such as Mr. Pullen has described is well illustrated by the fact that a quick check shows over 20 different materials or classes of materials mentioned in his paper. He has, therefore, wisely selected the approach to the problem of first laying down broad principles and then gathering specific information from all possible sources.

Speaking only for the limited field with which I am acquainted, that of oxygen and acetylene, there is a considerable amount of knowledge and engineering and planning assistance available at all times to those who handle and use these gases, and the apparatus for putting them to useful work. The more American industry approaches the problem of handling hazardous materials, both gaseous and liquid, in the manner Mr. Pullen has outlined, the safer American plants will be as places to work.

Herbert E. Ryerson: Many of the points Mr. Pullen brought out bear repeating. A very important one on purging and inerting jobs is the preliminary work that should be performed jointly by the operating, fire, safety, and engineering departments. In conference, each department should be informed of what its function is to be, and all personnel should be thoroughly instructed as to their duties before any operations begin.

All too frequently, when new projects are being designed, too much attention is given to production and not enough emphasis placed on safety and adequate fire protection. Actually, if the fire extinguishing system is not properly sized, conflagrations can develop which will wipe out an entire operation. Some of these fires can start from poorly organized and improperly performed inerting jobs.

We happen to be familiar with the steel mill where Mr. Pullen is located, and there is very close liaison maintained between the fire department and the operating personnel. Actually, the fire department personnel operate the inerting equipment and sufficient fire personnel is on duty during a purging operation to ex-

tinguish a fire should one develop. This possibility is very remote, as more than safe limits are always maintained prior to, during, and after a purging job. This fire chief is constantly in touch with operations.

Mr. Pullen is to be complimented on his paper and its presentation. However, it might be considered as only a general introduction to the subject, as Mr. Pullen has been in charge of many difficult inerting jobs which he has not even touched on in this paper. It would be very instructive and informative if Mr. Pullen would continue this discussion next year, and give you some actual case histories. The time saved on many projects is amazing. Mr. Pullen is now accomplishing in hours what used to require days, and this work is being done more safely. This safer operation reduces the mental hazard of injury to the worker, which in turn allows him to perform a better job.

R. W. Stanford: Mr. Pullen referred to flushing certain products down the drains or sewer lines. Do we not create a hazard in doing that, and how do we know that we have not, especially if they are volatile liquids, created a serious condition some other place in the plant sewer lines?

L. A. Terry: Who in your organization makes the tests for explosives or toxic mixtures? Is it personnel from your chemical laboratory, combustion department, pipe fitters or safety department?

F. Bruce Bevelheimer: I might add in our own plant, at Ford Motor, that we have abandoned steam purging almost completely with the exception of very few lines, and we do have two in our gas purging machines. We have made portable machines. One is quite a large unit, with which we can purge almost any line in the plant within about three hours. They are usually kept in shape for a purging job, and we do get them sometimes with very little notice.

Member: There was a job out in the Chicago area that they wanted to get the gas lines secured safely during the strike. On that particular mill they used over a hundred tons of carbon dioxide in completely filling the entire gas line system, and it stayed in there during the entire strike. The reason for that was the mill is so situated that anybody with a high-powered rifle with an incendiary bullet could have shot into that line and completely exploded it if the gas and air mixture was right.

F. R. Pullen: As to the question of flushing the volatile liquids into the sewer, it is possible. Generally speaking, when we are talking about volatile liquids we are talking about something volatile at a given temperature or above. You probably would not give off much in the way of vapors in flushing in cold water, although that water mixture may wash down into a sewer and mix with some hot water. In that event it may be necessary to pump into a tank car and haul it away to a safe disposal area.

As to who tests and who carries on the tests for concentration of the gases, etc., that probably differs in just about every plant. I know it differs in the plants within our own corporation. At Sparrow's Point plant, for example, the fire department does the testing. In our plant, Johnstown, the combustion department does the testing. I think that is the case in most other plants in our own corporation.

We do not think there is any necessity of the chemical laboratory, or someone of that nature, doing the testing. In fact, we do not feel they are familiar enough with all of the problems involved to do that work, and we do not think particularly that the mechanical department should do this testing, because they are, at least should be, quite anxious to get started on jobs and may shortcut to get started, particularly if they have a time deadline to beat, as is the situation in most cases.

So, we felt in setting up our program the testing should be done by a department entirely separate from the operating department and from the maintenance department. Anyone that is sufficiently trained can fit into that category and can do the job. Testing in most cases involves just a matter of operating instruments of some type, possibly Bureau of Mines explosive meters, or things of that nature, and just about anybody can be taught to use them in a very short time.

F. Bruce Bevelheimer: I would like to say I am not in favor of using steam lines. I went through a few experiences where someone insisted that we purge underground lines with steam. Yes, it has been done very successfully, so, a short time after, we found out that all of our leaded joints had slipped and we were leaking at every joint. I sure would not want any more such jobs.

MINES BUREAU REPORT DISCUSSES PRECISION OF COKE SHATTER TEST

Recommendations as to the size and number of coke samples needed to obtain a certain precision in the shatter test for determining coke strength are given in a Bureau of Mines report released by Secretary of the Interior Douglas McKay.

The Bureau investigated the shatter test as part of its program to develop more reliable procedures for determining the physical qualities of coke used by the steel and allied industries.

Precision of the test was evaluated for several cokes produced in regular coke plant operation. Control of size consist, weight of samples, and moisture content of samples were investigated as possible factors affecting test reproducibility. Control of size consist gave better test precision, but variations in weight of samples ranging from 22 to 75 pounds and moisture content up to 10 per cent were found to have no measurable effect on results. Elaborate subsampling procedures did not materially improve test precision.

Real improvement in precision, the Bureau's report states, can be attained only by increasing the total amount of coke tested.

A free copy of Report of Investigations, "A Study of the Precision of the Shatter Test on Coke," PN. 44716 can be obtained from the Bureau of Mines, Publications Distribution Section, Pittsburgh 13, Pa. It should be identified by number and title.

CAUSES AND PREVENTION OF PREMATURE GEAR FAILURES

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. . . . it is easier to keep out of trouble than to get out of trouble . . . .

▲ THE science of gear design and manufacture has advanced such that today gears and their bearings should last as long as the machine of which they are a part. However, it sometimes seems gears behave as anticipated only on the drawing board; so here it is our purpose to look into some of the causes and the appropriate steps to prevent these premature gear failures that account for such an unnecessarily large part of the maintenance costs in the steel industry.

This paper is intended to identify the major contributory causes of gear failures and to correlate gear design and operation with lubricant function.

The first half of the paper has been prepared so as to be of direct interest to the lubrication engineer and to the staff he directs, since it is one of their principal duties to be informed as to the performance and condition of every gear train in the plant.

Despite the thousands of drives on mill auxiliaries, it is mill drives and pinions that generally come to your mind when we talk of gear drives in the steel industry. As the classification and identification of the causes of gear failure are to a large degree the same whether for mill drives and pinions or the smaller and more numerous mill auxiliary drives, we will reserve until the latter half of the paper reference to the special problems presented by the mill drives and pinions. A small plant may have 150 cranes, each with two or more independent gear drives, in addition to mill tables, shears, pushers, conveyors and other materials handling equipment, all of which operate at speeds slower than that of their motors. Drives for mill auxiliaries, because they are more representative of the commercially available drives of the gear industry and because there are so many more of them, will represent the basis of our present discussion. I will take up first gear tooth surface failures and their causes with reference primarily to enclosed gears that are flood lubricated by splash or circulation systems.

Surface failure is often attributed to deficient lubrication; actually tooth surfaces may be destroyed by any one of the following five basic causes: tooth surface irregularities, abrasives in the oil, mechanical damage to teeth, metal failure, or lubricant failure. These five basic causes of premature surface failure may in turn be brought about by such design, installation or operating conditions as overheating, shock, loose bearings, improper alignment, or deflection of shafts or housings, etc. Following the American Gear Manufacturers Association standard nomenclature, the major types of wear and failure will be identified, respectively, as *Pitting*, *Abrasion*, *Scratching*, *Spalling* and *Scoring*. Taking the causes of tooth surface failure in that order, we will start with:

Tooth surface irregularities — The microscopically rough surface and variations in hardness or hard spots of new gears cause uneven distribution of load over the surfaces of the teeth in contact. This load is momentarily concentrated on the pitch line as each tooth passes through mesh in rolling contact. Sub-surface fatigue of the high points of the metal results in pitting along the pitch line. Minute particles break away, leaving small pits where there were high points or hard spots. It is considered to be a normal development in the process of mating and usually stops after the load has

been uniformly distributed over the surface. However, if too much of the load-carrying surface is destroyed, pitting becomes progressively worse.

With worm gears, sliding contact predominates in all contact areas and high spots are worn away before pitting can occur. The term "worm wheel pitting" actually refers to a condition known as "spalling," which is a metal failure, not surface roughness.

If the gears are properly lubricated, in accurate alignment, and not overloaded, the rolling and sliding action of the teeth will smooth out imperfections of manufacture and work-harden the surfaces to a high polish.

Abrasives in the Oil follow next. Abrasion of tooth surfaces is caused by particles in the lubricant that are larger than the thickness of the lubricating oil film. These abrasives come from sand, scale or metallic particles in improperly cleaned housings, through the breather or seals, introduced with the lubricant, or from the gear teeth or bearings. Evidence of abrasive particles in the oil is characterized by many parallel scratches in both the addendum and dedendum of the teeth. If the abrasives are very fine, the scratches may not be individually apparent, but there will be excessive tooth wear and loss of tooth contour.

Mechanical Damage to Teeth is caused by a nut, bolt or similar object falling between two gears or to jamming of driven equipment. The damage to one or both teeth of the mating gears mars or scratches subsequent teeth engaging with the damaged tooth. Where scratching develops from other surface failures, such as aggravated pitting or scoring, the loss of tooth contour is severe and rapid.

Metal Failure of the tooth surfaces occurs when the elastic limit of the gear material has been exceeded. In case-hardened gears it results in rippling of the tooth surfaces. Fracture follows the case-core line with fatigue failure occuring at the roots. Occurence of the loss of large chunks of the tooth at the tip indicates failure due to impact.

On unhardened gears under similar conditions of loads exceeding the yield point of the metal, spalling takes place with tooth surfaces showing plastic flow with a fin at the tip of the tooth. Uniform heavy loads cause "rolling" of the tooth surfaces, while uneven overloads or shock loads result in "peening." As the direction of slide differs for the driving and driven gears, it will be found that the flow of metal on the tooth surface of a pinion or driving gear, will be away from the pitch line, and for the driven gear, towards the pitch line.

The last of these five general classifications is *Failure of the Lubricant*. Failure of the lubricant oil film to carry the load may be attributed to unusually severe operating conditions or to incorrect lubricant selection.

Under certain conditions molecular adhesion or welding, develops from the pressure speed or temperature exceeding the limits of the lubricant. Welding damages both tooth surfaces, which are then dragged or torn from root to tip with score lines showing perpendicular to the pitch line.

In addition to the usual causes of overload, there are two additional conditions which should be covered, namely: *Misalignment* and *Thrust*. With misalignment, if the shafts on which the gears are mounted are not properly positioned, the load is carried on a small portion of the tooth surface. Any of the aforementioned conditions of overload can result.

Early indications of misalignment are a burnished area perpendicular to the pitch line at one end of the tooth on the load side. In severe cases this area will also appear on the back of the tooth at the opposite end.

With regard to *Thrust*, this may show up as interference on bevel gears. On herringbone gears, one helix will show overload. On double enveloping worm gears the worm will show conditions of overload on either the entering or exit end.

As an example, take a herringbone gear train. It can be readily appreciated that one shaft must be located and fixed in position and the other shafts mounted on bearings that allow free movement so that the gearing may float to center itself equalizing the load over right and left-hand helical faces. The most approved and satisfactory method of accomplishing this is a bearing selection with the combination radial-thrust bearing supporting the low speed or largest shaft and gear of the train, and cylindrical roller bearings supporting the remaining members. In this bearing selection, tapered roller bearings are used on the low speed shaft. Cylindrical roller bearings having land riding machined bronze cages rather than roller riding stamped metal cages are a recommended refinement in selection for the intermediate and high speed shafts.

Thrust is also caused by improper selection or mounting of the couplings. After mounting, for instance, the operating position of the couplings should be checked on the shafts to avoid the possibility of thrust from one shaft to the other. In the coupling selection there should be due regard for a design that will permit the motor rotor to locate itself axially under varying torque requirements without transmitting thrust to the pinion shaft. The coupling design selected should also be able to take care of minor shaft misalignment resulting from slight inaccuracy in initial alignment, as well as from subsequent settling of foundations.

It is a common fallacy to attribute to flexible couplings the ability to absorb considerable shaft misalignment. Actually, with any one of the present-day designs of the self-aligning gear type couplings, for instance, they are capable of absorbing only a few hundredths of an inch displacement in the alignment of the center lines of the two shafts and a total of 2 or 3 degrees maximum in angular misalignment.

Shaft misalignment also often results from the use of the relatively light welded steel type base cataloged and commercially available, not the heavy steel base of proper design and adequate section. This built-up welded plate base introduces the added factor of vibration. Contrast that construction with the rugged, dimensionally stable cast *alloy-iron* bedplate made of heavy box section, and having finished pads on top to receive the motor and speed reducer drive. Such a substantial, high tensile cast iron base should be regarded as an investment improving the general character of the drive installation throughout its entire life. And it may often be counted on to show a marked saving at the time of erection. An analogous comparison is the

Figure 1 — Normal wear.

Figure 2 — Abrasive wear.

welded steel pulley and the machine moulded, high test cast iron pulley with machined crowned or straight face. This modern, high tensile cast iron pulley is, generally, the accepted pulley selection for use in the steel industry on belt conveyors.

The American Gear Manufacturers Association, Empire Bldg., Pittsburgh 22, Pa., has published a standard No. 110.02 entitled "Gear Tooth Wear and Failure" in which twenty pictures are shown of the different types and stages of gear tooth failure with explanations of each. A copy of this bulletin should be available to every design engineer, lubrication engineer and maintenance superintendent.

The following figures follow the sequence and general terminology of the previously mentioned AGMA bulletin. Comments on each will be in the following order: (1) appearance, (2) early indications and (3) lubrication. Figure 1 shows normal wear on a gear.

Figure 2—Abrasive Wear (Figure 2 of AGMA Standard)

1. Note the many parallel scratches in both the addendum and dedendum of the teeth. If the abrasives are very fine, the scratches may not be individually apparent but there will be an obvious loss of tooth contour.
2. The first inspection will show a few scattered scratches. Examination with a magnifying glass of a dried section of the tooth will show deep scratches along with the fine shallow scratches of normal wear.
3. Although the lubricant is correct as to grade and type, it is dirty and should be removed and the housing thoroughly cleaned. Perhaps the filter of the breather is at fault, or particularly abrasive or dusty atmospheres calling for more frequent inspection.

Figure 3—Scratching (Figure 3 of AGMA Standard)

1. This condition is obvious. In advanced cases the loss of tooth contour is severe and rapid.
2. The only early indication of scratching is a few deep scratches. The unit should be drained and cleaned as soon as these are observed.
3. The lubricant is not at fault but is contaminated and must be replaced and the housings cleaned.

Figure 4—Overload Wear (Figure 4 of AGMA Standard)

1. The appearance of this form of failure is a combination of deep scratches and flaking of the surface usually in the addendum of the driven gear and the dedendum of the driving gear or over the entire surface. The cause is excessive load on hardened or unhardened gears with low pitch line velocities.
2. Although the surface temperature is not high enough to cause welding, the temperature of the lubricant and tooth surface will be fairly high.

Figure 3 — Scratching.

Figure 4 — Overload wear.

A few scratches similar to that described under "scratching" will be seen at first but the presence of elevated temperature will distinguish it from that caused by large particles.

3. Lubrication is not at fault although too light a grade or too low a viscosity index will accelerate this condition.

Figure 5—Rolling and Peening (Figure 6 of AGMA Standard)

1. The metal surface will show a pronounced deformation with the plastic flow producing a heavy fin at the tip of the tooth.
2. The initial indication of this difficulty is a burnished surface over the entire tooth, on certain teeth or on certain positions on the tooth. In order to distinguish this from the satin finish of normal wear the tooth surface must be dry.
3. This is a form of metal failure.

Figure 6—Slight Scoring (Figure 8 of AGMA Standard)

1. The surface of the tooth shows score lines perpendicular to the pitch line. A pit can be observed at the base of some of the lines where a chunk of metal has been torn out and welded to a mating tooth.
2. High tooth surface temperature is a forerunner of this condition. A few scores with the characteristic pit at the base is all that should be required to start immediate corrective action. The sequence of heat, slight scoring, severe scoring is rapid and positive.
3. If a straight mineral oil has been used of the proper viscosity for the speeds and loads then this can be credited as a lubrication failure and represents the selection of the wrong type. If a mild extreme pressure lubricant has been employed then the failure should be charged to overloading.

Figure 7—Severe Scoring (Figure 9 of AGMA Standard)

1. The surface condition shown represents the advanced stage of molecular adhesion. The pits are larger and more frequent. In a relatively short time after this condition is observed, there will not be any tooth left.
3. The comments on lubrication stated for "slight scoring" also apply to this picture.

Figure 8—Initial Pitting (Figure 10 of AGMA Standard).

1. A series of very small pits may develop along the pitch line of gears shortly after they are put in operation. This is termed "initial pitting." It is considered to be a normal development in the process of mating and usually stops after the load has been uniformally distributed over the surface.
2. The first few pits develop immediately after the gear is put in operation. When this is observed, the tooth should be cleaned and dried. If the remainder of the tooth surface indicates normal wear then there should be no further concern. If some of the pits are fairly large and the dedendum of the driving pinion shows a burnished condition, then the initial pitting can develop into a condition of "destructive pitting."
3. The lubricant is completely successful, but it may be contaminated with fine metallic particles carried in suspension.

Figure 5 — Rolling and peening.

Figure 6 — Slight scoring.

Figure 7 — Severe scoring.

Figure 8 — Initial pitting.

Figure 9 — Destructive pitting.

Figure 10 — Corrosive wear.

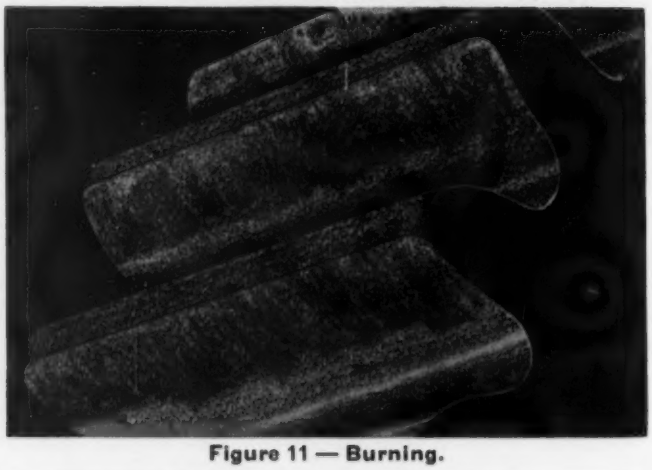

Figure 11 — Burning.

Figure 12 — Interference.

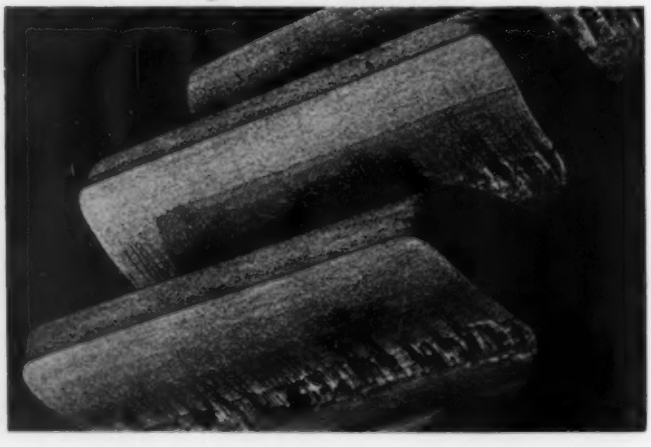

Figure 9—Destructive Pitting (Figure 11 of AGMA Standard).

1. This condition is characterized by a large number of fairly large pits over the central portion of the tooth surface of the whole tooth. It is easy to picture the widening of these craters with the walls of the pits crumbling away.
2. One or more off pits the pitch line should be the signal to start corrective measures, which will be covered later.
3. Lubrication has been successful. There is nothing that can be done to the lubricant to reduce this condition.

Figure 10—Corrosive Wear (Figure 13 of AGMA Standard).

1. The surface consists of intermittent lines of deeply etched out pits, the lines being parallel to the pitch line. The remainder of the tooth surface may have a frosted appearance when dry. The cause of this condition is chemical action by contaminents in the lubricants or oxidation of the lubricant. Contaminents of either high or low pH can cause displacement of the lubricant from the surface and permit the direct action aginst the metal during periods of rest.
2. Contaminents which are strong enough to attack metals usually cause lubricants to hold water in suspension. The cloudy appearance of the lubricant is an early indication. Small patches of frosted surface can also be seen on a dry tooth surface.
3. Although the selection of the grade and type of lubricant is correct there is no excuse for allowing the lubricant to get in such bad condition. Poor lubrication housekeeping must be charged with this failure.

Figure 11—Burning (Figure 14 of AGMA Standard)

1. The evidence of burning is a discoloration of the surfaces. There is a loss of hardness with this type of failure. The excessive heat can be caused by overload, overspeed, lack of backlash, or faulty lubrication.
2. Very high temperature of the housing and smoke coming out of the breather are external evidence of this condition.
3. If the lubricant used is a high viscosity index, extreme pressure type, then this type of failure can not be charged to lubrication. For more thorough treatment of this subject refer to the paper by B. W. Kelley of the Caterpillar Tractor Co. entitled "A New Look at the Scoring Phenomena of Gears."

Figure 12—Interference (Figure 15 of AGMA Standard)

1. This type of failure is evidenced by a severely gouged out area at the root of the tooth. The cause of this condition is too close a center distance for the tooth profile, or inadequate tip relief incorporated into the tooth form.
2. Since it is impossible to cut or generate large gears and pinions to allow for exact deflection curves under varying loads, a compromise tip relief is often incorporated into the tooth form. It also increases contact ratio as wear progresses, im-

proves lubrication efficiency, and helps pick up spacing errors gradually.

3. Lubrication is not involved in this type of failure.

Figure 13—Grinding Checks (Figure 16 of AGMA Standard)

1. Although not evident on new gears the checks or fine lines that appear after the gear is put in operation usually follows a definite pattern.
2. The lines develop so soon after the gears are put into operation that there is no advance indication of the difficulty.
3. Lubrication is not a contributor to this condition.

Figure 14—Overload Breakage, (Figure 17 of AGMA Standard)

1. With overload breakage, large sections or an entire tooth is broken off. The fracture shows a uniform crystalline surface, having somewhat the appearance of cast iron.
2. Lubrication not involved.

Figure 15—Fatigue Breakage (Figure 18 of AGMA Standard)

1. The general appearance of fatigue breakage is smoother than "overload breakage." Close examination of the fracture will sometimes show the characteristic fatigue lines radiating from the edge on the load side of the tooth.
2. The early indication of this condition can be observed only on a dry tooth with the aid of a magnifying glass. It consists of a very fine line either diagonally across the tooth or along the tooth in the dedendum just above the fillet.
3. The lubricant plays no part in this condition.

Figure 16—Cracking (Figure 19 of AGMA Standard)

1. The characteristic appearance of this type of failure consists of hair line cracks extending in any direction and on any area of the tooth surface. These cracks are caused by residual stresses introduced in the hardening process.
2. These cracks become apparent shortly after the gear is put in operation. If the gear is lightly loaded there may be no immediate cause for alarm. If the gear carries a normal or heavy load the cracks become starting points for fatigue failure.
3. Lubrication successful.

Figure 14 — Overload breakage.

Figure 15 — Fatigue breakage.

Figure 16 — Cracking.

Figure 13 — Grinding checks.

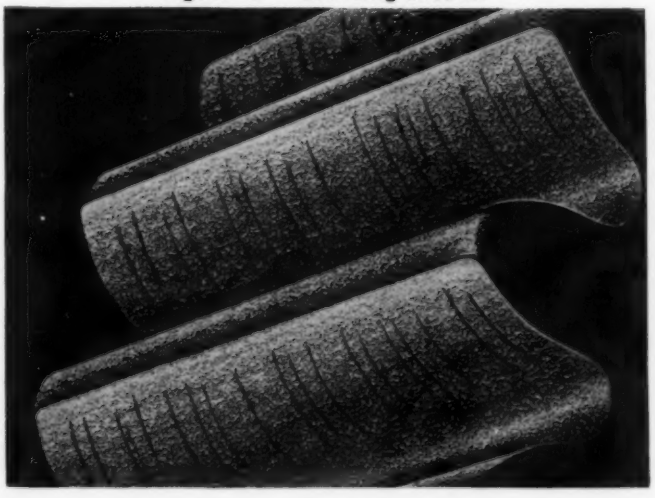

Figure 17 — Quenching cracks.

Figure 17—Quenching Cracks (Figure 20 of AGMA Standard)

1. Fine check lines extending in all directions over most of the tooth surface. Occasionally small chunks fall out giving the false indication of destructive pitting. This condition is caused by improper heat treatment.
2. The early indication of this condition can be observed by examining the dry tooth surface with magnifying glass.
3. Lubrication successful.

In most of the examples of gear tooth surface deterioration shown on the figures, the major portion of the service life of the gears is gone. Early indications of impending gear difficulties actually are easily diagnosed as to the prime cause. Too frequently the inspection hole is opened and the gears looked at with a weak flash light. If there is enough tooth left to last until the next inspection, nothing is done about it. This form of inspection is only good for finding broken teeth or teeth missing large chunks. In order to determine accurately the condition of the gears, the tooth being inspected must be cleaned off with carbon tetrachloride, or other solvent, and dried with a clean cloth.

It is important that gear trains be inspected thoroughly and at regular intervals in order to obtain the full service life for which they were designed. On all large and important gear trains, a new unit should be inspected at the end of the first, third, sixth and twelfth month and annually thereafter. Any unusual noise or heat from the gear case, or overloading of the motor, indicates an immediate inspection is necessary.

It is generally recognized today that lubricants are the blood streams that maintain the life of moving mechanisms. The old rule that a chain is as strong as its weakest link applies in particular to the operation of gearing. One of these links is lubrication. The type and grade selected and the lubrication maintenance followed are just as important as the design of the gears, type of tooth form incorporated, accuracy of machining, accuracy of assembly, and control of operating factors. This paper is not concerned with the subject of lubricant selection, but observations on the basic elements of gear lubrication will be of interest to the maintenance and equipment engineers as well as to the lubrication engineer.

It is now generally recognized that adequate gear protection need not depend on lubricant viscosity alone. The lubricant must have the proper viscosity and viscosity index to provide the proper operating viscosity or body of film to realize the maximum hydraulic pressure under conditions of the heat developed by the surfaces in contact and must also have sufficient film strength. Additional qualities of the oil to be considered are lubricity or oiliness at operating temperatures to reduce frictional loses in gear assemblies, adhesive qualities to resist centrifugal forces, oxidation stability, and low acid forming tendencies. Many of the new synthetic compounds take these factors into consideration. Extreme pressure lubricants of today, for example, provide the high film strength required for applications that formerly were considered impractical.

The two general types of additive oils recognized by AGMA are the chemical type and the physical type. The latter referred to as the "mild" type, has a decided advantage for industrial gears in that the lead soap is an excellent lubricity agent. In industrial gear lubrication, where the physical type extreme pressure lubricant is inadequate, the chemical type will be of little additional benefit. With additive oils, lubrication is still by the thick film mechanism up to the limits for the base oil. Beyond these limits the thin chemically formed and absorbed film of the "powerful" chemical type may eliminate welding with subsequent scoring, but chemical wear may show up.

To appreciate the factors to be considered in gear lubrication, it is necessary to be familiar with the characteristics of the involute tooth form as it passes through mesh. With involute gears, which is the only tooth form covered here, contact takes place along a line with the relative surface movements consisting of a combination of slide and roll. Contact on the driven gear starts at its tip and moves rapidly toward the pitch line, but with the pinion it starts just below the pitch line and moves slowly towards its pitch line. The *relative* movement of the gear and pinion tooth surfaces lessens as contact progresses reaching full rolling motion on the pitch lines at the point where the line of contact passes through the line of centers. The angle of the line of contact, or the pressure angle, is fixed throughout mesh. As mesh continues, contact on the driven gear moves at a decreasing rate towards the dedendum and on the pinion at an increasing rate as the teeth pass out of mesh.

The wedge of lubricant that developed at the start of mesh continues through mesh with the hydraulic pressure within the fluid directly dependent on the relative movement of the tooth surfaces. These pressures are modified by the consistency of the angular velocity, flexing of the teeth, compression of the surfaces at the point of contact, accuracy of tooth profile, and the surface finish. It should be noted here that the increasing tendency to high hardness gears to reduce wear and increase tooth loading overlooks the requirements for correspondingly higher hydraulic pressures to oppose the heavier applied pressure.

Higher hydraulic pressures may be accomplished, however, by the long and short addendum modification of the full depth involute tooth. The addendum of the pinion is lengthened and its dedendum shortened. On the gear the addendum is shortened and the dedendum lengthened. The long-and-short addenda tooth modification, in addition to improving the involute action of the gearing, also eliminates undercut.

The stub tooth gear is another modification that is receiving some attention. It provides greater strength to withstand impact or shock loads, but as both the addendum and dedendum are shortened, the resulting lower lubrication efficiency reduces permissible tooth loading.

Discussion of lower lubrication efficiency brings to mind the special problems relating to mill drives and pinions referred to earlier. This brand of reduced lubrication efficiency is altogether different, however, having to do with oil contamination. It is a common axiom that maintenance diminishes the farther you get away from the mill. But keeping out scale and water, as important as it is, is only one problem contributing to the

frequently encountered conditions in these drives of destructive pitting. Another major contributory cause is the practice of exceptionally wide faces which makes it difficult to obtain full face contact with uniform unit pressures over the tooth surface. The combination of torsional deflection, bending deflection and tooth deflection is aggravated. Other gear design factors with specific reference to special problems relating to mill drives and pinions will be covered by Mr. Walter Matthews in the discussion period after this paper.

There has been some interest expressed in a comparison of the relative advantages and disadvantages of the 14½ degree pressure angle and the 20 degree pressure angle. With the flatter 14½ degree pressure angle, bearings are less heavily loaded. This amounts to somewhat longer bearing life. On the other hand, the base of the tooth is narrower resulting in a lower beam strength. This lower tooth strength is jeopardized further due to undercut in pinions in the standard 14½ degree full depth involute tooth form having 32 teeth or less, with progressively more undercut as you go to fewer and fewer teeth.

In addition to the huskier tooth form for the 20 degree pressure angle, undercut on the pinions does not show up until you have 18 teeth or less. Also, undercut is further reduced or eliminated by the introduction of the long and short addenda modification. Also favoring the 20 degree pressure angle full depth involute tooth form is a higher relative surface movement with correspondingly higher lubrication efficiency under conditions of full fluid film lubrication. Along with the important higher hydraulic pressures, the total contact is distributed over a broader portion of the tooth surface.

Although this paper has purposely omitted formulae and technical detail, we have fairly well established the theory of correct lubrication under conditions of normal wear as merely one of hydraulics. The selection and characteristics of the lubricant employed should be such that the maximum hydraulic pressure will develop under the operating conditions, so that the surface pressure between the teeth in contact will be held at the lowest values. With the improved distribution of load and reduction of wear, smooth, quiet operation can be expected. There is little justification for the mill auxiliary drives to operate under any less favorable conditions, excepting possibly, on older installations having gear shafts supported in plain bearings. But a number of these installations are being modernized and rebuilt incorporating the present-day heavy duty tapered roller bearing pillow blocks. Just as a combination of tapered and cylindrical roller bearings assure accurate and sustained parallelism of the shafts and positively fix the gearing centers of a modern speed reducer drive, so the same accurate and sustained gear centers, assuring maintenance of the designed tooth conjugation, can be realized with the shafts of open gear drives mounted in hard bearings.

The advantages and disadvantages of the different types of gears, such as spur, worm, straight bevel, spiral bevel, hypoid, single helical, herringbone, etc., are a subject in themselves, but also as that is more the concern of the gear drive design engineer, I will not include it here, I refer instead to the very fine paper presented by Mr. E. C. Denne, entitled "Some Aspects of Selecting and Applying Gears for Rolling Mill Equipment," 1951 Proceedings of the AISE.

There are several observations which I would like to submit that may enable the maintenance engineer and the equipment or design engineer to enjoy fuller advantage of the dependability built into the important, speed reducer drives of today. I have in mind the compact and highly efficient parallel shaft herringbone reducer, the right angle worm gear speed reducer, and the rugged worm-helical vertical reducer. Speed reduction units, as recommended for mill auxiliary drives, may be expected to operate for many years of trouble-free service provided they are operated at loads not exceeding the capacities for which they were sold and have been given proper lubrication and maintenance care.

In the first place, gear boxes should not be treated as pumps. The oil level should always be kept in strict accordance with the manufacturer's specifications. The proper static oil level is marked on the outside of the housing, but there is a tendency to overfill, which will cause churning and overheating.

Another cause of overheating is a dust laden housing. It is often overlooked that a layer of dust on a housing has high insulation properties.

Two final areas of comment have to do with (a) speed reducer selection, and (b) high and low speed shaft overhung load capacities. These two subjects along with flexible coupling selection are the simplest and yet the most difficult problems that confront the speed reducer sales engineer. His interests are very definitely the interests of the ultimate user, but for a number of conflicting reasons it is difficult to obtain sufficiently complete information to enable him to select the proper size machine. Sometimes the equipment builder, or contracting equipment supplier, has inadequate specifications as to the requirements of the equipment to be furnished. Such information might include the shock or peak loads to be encountered, reversing loads, such as on a transfer car, and hours per day of operation.

Now, it is the direct responsibility of the design engineer, not only to provide specifications containing this vital information either to the contracting equipment supplier or to the speed reducer sales engineer, but to see to it that his specifications are followed and strictly adhered to. When we specify AGMA Class III service rating for an enclosed herringbone gear drive, a machine selected with 133 per cent service factor should not be accepted. In steel mill service, due to the ever-present ingenuity of the operators to increase production, it is good engineering practice to apply the service factor to the rated motor horsepower rather than to the calculated horsepower. If a heavy duty type roller bearing machine has been specified, why should we accept a plain bearing or a ball bearing machine? Furthermore, there is little, or no, difference in price.

It often has been a simple expedient to specify, for instance, a 50-hp drive. That is the motor designation! What about the interconnecting couplings, shafts, bearings and gearing? That is often left entirely to the equipment supplier—who frequently, is not a gear manufacturer and has to buy the costly gear drive. A

speed reducer is a torque machine, and because of varying ratios and input speeds, has no single, simple size designation. Comparatively, the motor is a simple animal with a nicely balanced rotor supported on two bearings and it merely rotates. The speed reducer, on the other hand, hour after hour, day after day, transmits the load through rapidly engaging gear teeth with high shaft and bearing stresses.

The most consistently lacking information are the motor characteristics. This is particularly serious in applications for the steel industry where, in addition to the customary tendency to overmotor, there is a predilection for mill type motors, whatever the service. A speed reducer is designed to take 100 per cent momentary overload for starting or shock load conditions. Mill type motors have a 300 to 450 per cent breakdown torque capacity.

The horsepower capacities, AGMA Class 1, as tabulated in the rating tables should be designated as Nominal Ratings since they are intended for use with service factors. The Nominal Ratings (AGMA Class 1 wherein the service factor is unity) permit of 100 per cent overloads for ordinary starting duty or for occasional momentary peak load requirements.

Nine service factors have been established for instance, in the AGMA "Standard Practice" to cover the range of usual applications for the parallel shaft herringbone speed reducer. Hence, before selecting reducers, the service factors should first be consulted to assist in making a proper choice of machines.

The service factors are based on three considerations: namely, the source of power or type of the prime mover, the character of load for the driven machine, and the hours per day of operation.

The above suggestions apply to ordinary operation where machines are usually started infrequently and run continuously for hours at a time after once being put in service. Horsepower requirements for starting or during momentary peak load periods should not exceed 200 per cent of the Nominal Ratings which is equal to 100 per cent overload for the AGMA Class 1 ratings as tabulated.

In some special applications, driven machines are required to start and stop frequently with relatively short running periods in between. When starting and stopping is repeated constantly in the normal operation of the driven machine, the maximum starting horsepower (rather than the normal horsepower required to operate the driven machine) should be multiplied by an appropriate service factor to obtain an Equivalent Nominal Rating.

Occasionally reducers may be over-motored, that is, for one reason or another a prime mover is supplied with normal and overload capacity considerably in excess of the reducer.

When drives are subject to excessive momentary loads, the starting or peak horsepower should be divided by 2 and the quotient used for determining an Equivalent Nominal Rating.

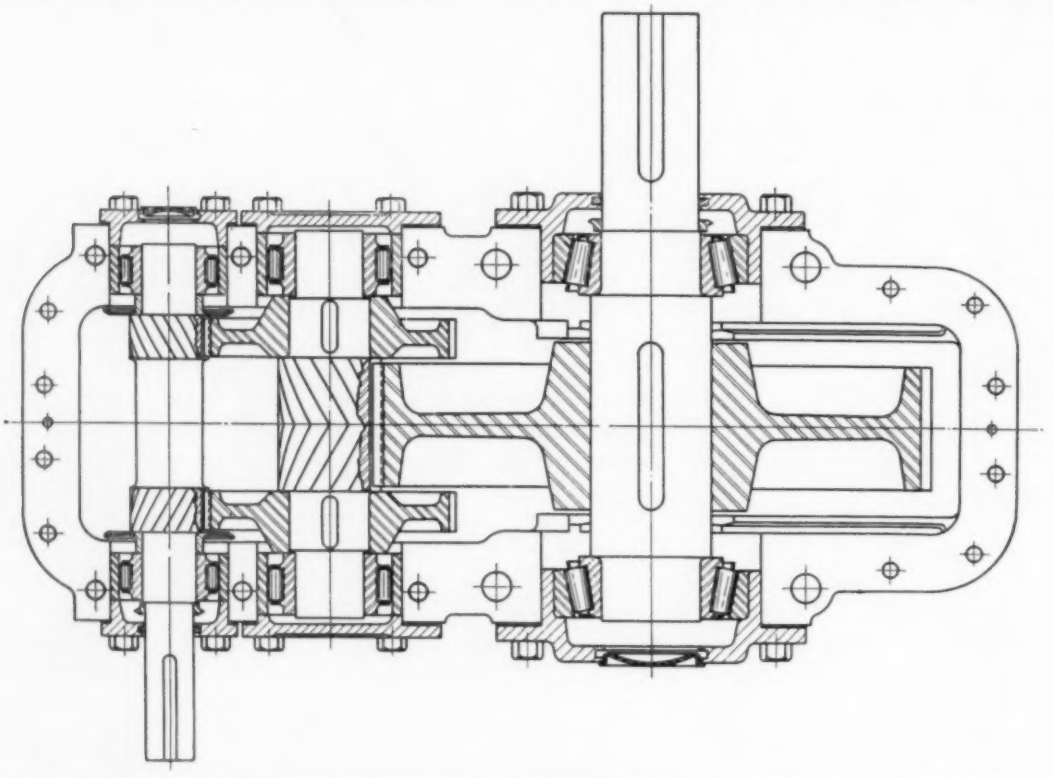

Figure 18 — Sectional view of herringbone reducer shows symmetrical arrangement of gears and bearings.

The service factors shown do not provide for extreme conditions of loading as may be found in the driving of certain reciprocating machines involving heavy recurrent shock or where severe pulsations or suddenly applied loads of considerable magnitude are present. Nor do they apply to reversing and overhauling drives where inertia in live rolls, fly wheel effect or other high energy loads prevail and must be absorbed. Drives to meet these specially severe conditions cannot conveniently be covered in a general way by predetermined service factors. Applications of this nature should be referred to the manufacturer for rating and selection.

Service factors are not to be applied to thermal ratings as their function is based solely on mechanical con-

siderations. The actual horsepower required for drives should not be in excess of the thermal ratings as these ratings represent the maximum average performance that can be maintained continuously for three hours or longer with safe or permissible increase in temperature conditions. Standard units are not equipped with special pump lubricating and cooling systems, therefore, the thermal ratings must not be exceeded for continuous operating drives.

Lastly, this paper will review briefly the frequently overlooked consideration of the high and low speed shaft overhung load capacities from V-belt sheaves, chain and sprocket and gear drives mounted on these shafts.

The resultant or equivalent overhung or external shaft loads may be calculated by transforming the horsepower transmitted into torque and dividing by the pitch radius of the pinion or sprocket and multiplying by a factor as shown below:

$$T = \frac{HP \times 63025}{N}$$

$$L = \frac{T \times F}{R} = \frac{HP \times 63025 \times F}{N \times R}$$

Where L = Resultant overhung load in lb
T = Torque in in. lb
R = Pitch radius of sprocket, pinion, etc., in in.

SERVICE FACTORS — TABLE A

Prime Mover	Duration of Service	Character of Load on Driven Machines		
		Uniform	Moderate Shock	Heavy Shock
Electric Motor	8-10 hrs. per day	1.0	1.25	1.75
	24 hrs. per day	1.25	1.5	1.75
	†Intermittent—3 hrs. per day	.8	1.0	1.5
	†Occasional—½ hr. per day	.5	.8	1.25
Multi-cylinder Internal Combustion Engine	8-10 hrs. per day	1.25	1.5	2.0
	24 hrs. per day	1.5	1.75	2.0
	Intermittent—3 hrs. per day	1.0	1.25	1.75
	Occasional—½ hr. per day	.8	1.0	1.5
Single cylinder Internal Combustion Engine	8-10 hrs per day	1.5	1.75	2.25
	24 hrs. per day	1.75	2.0	2.25
	Intermittent—3 hrs. per day	1.25	1.5	2.0
	Occasional—½ hr. per day	1.0	1.25	1.75

*This applies to normal size of motor selection in relation to load. For high torque or mill type motors refer to paragraph 7, page 20.
†Maximum momentary or starting load, must not exceed 100 percent of the normal operating load.

SERVICE CLASSIFICATION TABLE B

Class No.	Service Factor
1	1.0
2	1.25
3	1.5
4	1.75
5	2.0
6	2.25
7	2.5
8	.8
9	.5

A. G. M. A. NAME PLATE

Figure 19 — This typical catalog sheet shows service factor for application on speed reducer subject to various types of service.

CLASSIFICATION OF LOAD CHARACTERISTICS TO BE USED AS A GUIDE FOR SELECTING SERVICE FACTORS — TABLE C

UNIFORM LOAD	MODERATE SHOCK LOAD	HEAVY SHOCK LOAD
Agitators Pure Liquid Blowers Centrifugal Vane Brewing & Distilling Bottling Machinery Brew Kettles, Cont. Duty Coolers, Cont. Duty Mash Tubs, Cont. Duty Can Filling Machines Clarifiers Compressors Centrifugal Conveyors — Uniformly Loaded or Fed Apron Assembly Belt Flight Oven Screw Elevators Bucket (Uniform Load) Bucket (Continuous) Centrifugal Discharge Gravity Discharge Fans Centrifugal Light (Small Diameter) Feeders Disc Type Food Industry Cereal Cooker Generators (Not Welding)	Line Shafts Light Machine Tools Auxiliary Drives (Feed, Traverse, etc.) Metal Mills Draw Bench Carriage & Main Drives Mixers Constant Density Liquid Paper Mills Bleacher Conveyors Presses Suction Rolls Winders Printing Press Pumps Centrifugal Rotary — Gear Type Rotary — Other than Gear Type (Lobe-rune) Sewage Disposal Equipment Bar Screens Chemical Feeders Circline or Straight-line Collectors Grit Collectors Sludge Collectors Screens Traveling Water Intake Air Washing Stokers	Agitators Liquids & Solids Blowers Lobe Brewing & Distilling Brake Hopper, Frequent Starts Cane Knives Car Pullers Classifiers Clay Working Machinery Clay Working Machinery Pug Mill Compressors Lobe Reciprocating, Multi-Cylinder Conveyors, Heavy Duty-Dual — Not Uniformly Fed Apron Assembly Belt Bucket Flight Oven Screw Cranes & Hoists Main Hoists — Med. Duty Reversing Skip Hoists Travel Motion Trolley Motion Dredges Cable Reels Conveyors Maneuvering Winches Pumps Stackers Utility Winches Elevators Bucket (Heavy Load) Fans Cooling Towers	Induced Draft Induced Draft Large (Mine, etc.) Feeders Apron Belt Screw Food Industry Beet Slicer Dough Mixers Meat Grinders Laundry Washers Reversing Laundry Tumblers Line Shafts During Processing Equipment Machine Tools Other Machine Tools — Main Drive Mills — Rotary Type Ball Dryers & Coolers Kilns Pebble Metal Mills Slitters Table Conveyors (Non-Rev.) Wire Drawing & Flattening Machine Mixers Concrete Mixers (Continuous) Concrete Mixers (Intermittent) Irregular Density Semi-Liquid Oil Industry Refineries — Chillers Paraffin Filter Press Rotary Kiln Paper Mills Agitators (Mixers) Barking Drum Beater & Pulper	Calenders Couch Cylinders Dryers Felt Stretcher Stock Chests Pumps Proportioning Reciprocating — Single Acting — 3 or more cylinders Reciprocating — Double Acting — 2 or more cylinders Rubber Industry Rubber Calender Rubber Mill (2 or more) Sheeter Tubers or Strainers Sewage Disposal Equipment Dewatering Screen Scum Breakers Slow or Rapid Mixers Thickeners Vacuum Filters Screens Rotary — Stone or Gravel Slab Pushers Shearing Gear Textile Industry Ratchers Calenders Card Machine Dry Cans Dyeing Machinery Mangles Nappers Soapers Spinners Tenter Frames Looms Winders	Car Dumpers Clay Working Machinery Brick Press Briquette Machine Compressors Reciprocating, Single Cylinder Conveyors, Heavy Duty-Dual Not Uniformly Fed ‡Live Roll Reciprocating Shakers Cranes & Hoists Main Hoists — Heavy Duty Crushers Ore Stone Dredges Cutter Head Drive Jig Drive Screen Drive Elevators ‡Freight ‡Passenger Fans Cooling Towers Forced Draft Feeders Reciprocating Hammer Mills Machine Tools Punch Press & Gears Gear Drives	‡Notching Press — Belt Driven Plate Planers Mills — Rotary Type Rod Tumbling Barrels Metal Mills Forming Machines ‡Pinch, Dryer & Bridle Rolls (Reversing) Small Rolling Mill Drives ‡Table Conveyors (Reversing) Oil Industry ‡Oil Well Pumping Paper Mills Jordans Super Calender Pumps ‡Reciprocating — Double Acting — Single Cylinder ‡Reciprocating — Single Acting — 1 or 2 Cylinders Rubber Industry Mixer ‡Tire Building Machines ‡Tire & Tube Press Openers

‡Refer to Factory
§Dipper, Hammerhead, rotating and whirler — walker stationary or moving). Due to the nature of these crane drives, the following service factors are to be used for any duration of service. Main Hoist, 1.00; Auxiliary Hoist, 1.00; Boom (Luffing), 1.00; Rotating (Swing or Slew), 1.25; Trucking (Drive Wheels), 1.50.

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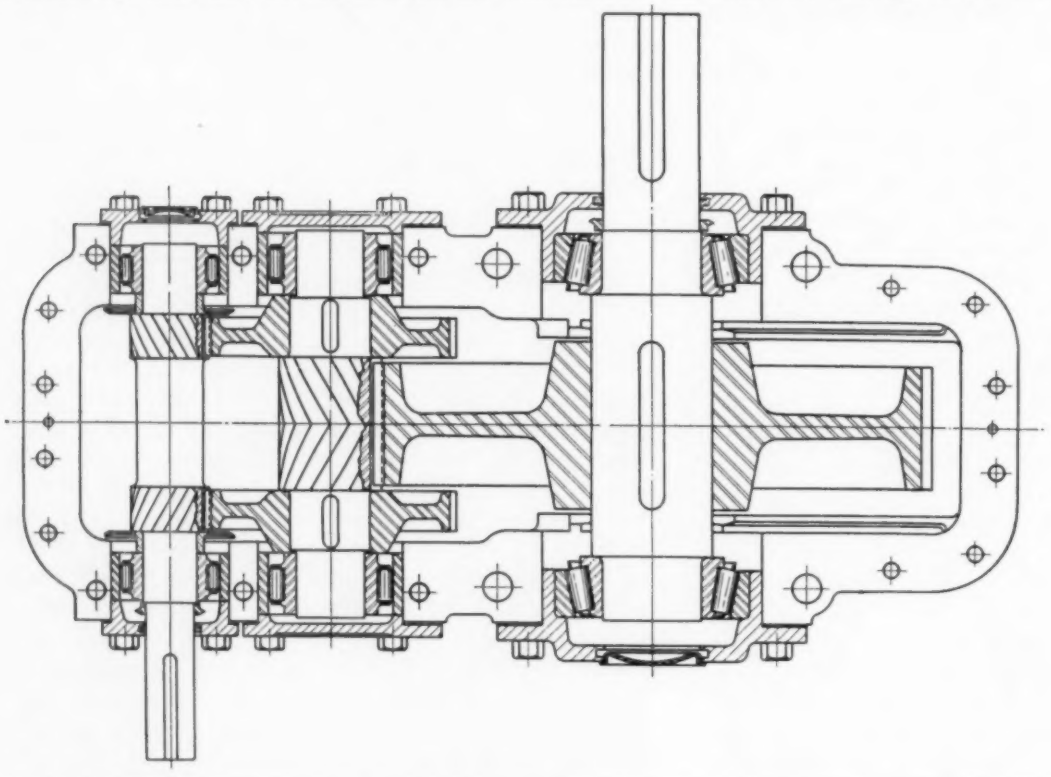

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	†Intermittent—3 hrs. per day	.8	1.0	1.5
	†Occasional—½ hr. per day	.5	.8	1.25
Multi-cylinder Internal Combustion Engine	8-10 hrs. per day	1.25	1.5	2.0
	24 hrs. per day	1.5	1.75	2.0
	Intermittent—3 hrs. per day	1.0	1.25	1.75
	Occasional—½ hr. per day	.8	1.0	1.5
Single cylinder Internal Combustion Engine	8-10 hrs. per day	1.5	1.75	2.25
	24 hrs. per day	1.75	2.0	2.25
	Intermittent—3 hrs. per day	1.25	1.5	2.0
	Occasional—½ hr. per day	1.0	1.25	1.75

*This applies to normal size of motor selection in relation to load. For high torque or mill type motors refer to paragraph 7, page 20.
†Maximum momentary or starting load, must not exceed 100 percent of the normal operating load.

SERVICE CLASSIFICATION TABLE B

Class No.	Service Factor
1	1.0
2	1.25
3	1.5
4	1.75
5	2.0
6	2.25
7	2.5
8	.8
9	.5

A. G. M. A. NAME PLATE

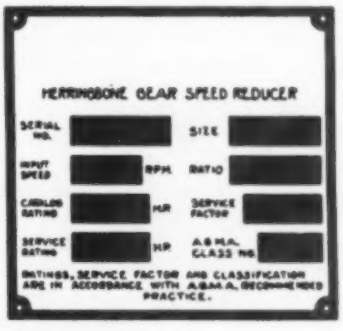

Figure 19 — This typical catalog sheet shows service factor for application on speed reducer subject to various types of service.

CLASSIFICATION OF LOAD CHARACTERISTICS TO BE USED AS A GUIDE FOR SELECTING SERVICE FACTORS — TABLE C

UNIFORM LOAD	MODERATE SHOCK LOAD	HEAVY SHOCK LOAD
Agitators Pure Liquid Blowers Centrifugal Vane Brewing & Distilling Bottling Machinery Brew Kettles, Cont. Duty Coolers, Cont. Duty Mash Tubs, Cont. Duty Can Filling Machines Clarifiers Compressors Centrifugal Conveyors — Uniformly Loaded or Fed Apron Assembly Belt Flight Oven Screw Elevators Bucket (Uniform Load) Bucket (Continuous) Centrifugal Discharge Gravity Discharge Fans Centrifugal Light (Small Diameter) Feeders Disc Type Food Industry Cereal Cooker Generators (Not Welding) Line Shafts Light Machine Tools Auxiliary Drives (Feed, Traverse, etc.) Metal Mills Draw Bench Carriage & Main Drives Mixers Constant Density Liquid Paper Mills Bleacher Conveyors Presses Suction Rolls Winders Printing Press Pumps Centrifugal Rotary — Gear Type Rotary — Other than Gear Type (Lobe-rase) Sewage Disposal Equipment Bar Screens Chemical Feeders Circuline or Straight-line Collectors Grit Collectors Sludge Collectors Screens Traveling Water Intake Air Washing Stokers	Agitators Liquids & Solids Blowers Lobe Brewing & Distilling Grain Hopper, Frequent Starts Cane Knives Car Pullers Classifiers Clay Working Machinery Clay Working Machinery Pug Mill Compressors Lobe Reciprocating, Multi-Cylinder Conveyors, Heavy Duty-Dual — Not Uniformly Fed Apron Assembly Belt Bucket Flight Oven Screw Cranes & Hoists Main Hoists — Med. Duty Reversing Skip Hoists Travel Motion Trolley Motion Dredges Cable Reels Conveyors Maneuvering Winches Pumps Stackers Utility Winches Elevators Bucket (Heavy Load) Fans Cooling Towers Induced Draft Induced Draft Large (Mine, etc.) Feeders Apron Belt Screw Food Industry Beet Slicer Dough Mixers Meat Grinders Laundry Washers Reversing Laundry Tumblers Line Shafts Driving Processing Equipment Machine Tools Other Machine Tools — Main Drive Mills — Rotary Type Ball Dryers & Coolers Kilns Pebble Metal Mills Sheers Table Conveyors (Non-Rev.) Mine, Quarry & Plant Wire Drawing & Flattening Machine Mixers Concrete Mixers (Continuous) Concrete Mixers (Intermittent) Irregular Density Semi-Liquid Oil Industry Batteries — Chillers Paraffin Filter Press Rotary Kiln Paper Mills Agitators (Mixers) Barking Drum Beater & Pulper Calenders Coach Cylinders Dryers Felt Stretcher Stock Chests Pumps Proportioning Reciprocating — Single Acting — 3 or more cylinders Reciprocating — Double Acting — 2 or more cylinders Rubber Industry Rubber Calender Rubber Mill (2 or more) Sheeter Tubers or Strainers Sewage Disposal Equipment Dewatering Screen Scum Breakers Slow or Rapid Mixers Thickeners Vacuum Filters Screens Rotary — Stone or Gravel Slab Feeders Shearing Gear Textile Industry Calenders Card Machine Dry Cans Dyeing Machinery Mangles Nappers Soapers Spinners Tenter Frames Looms Windlass	Car Dumpers Clay Working Machinery Brick Press Briquette Machine Compressors Reciprocating, Single Cylinder Conveyors, Heavy Duty-Not Uniformly Fed ‡Live Roll Reciprocating Shakers Cranes & Hoists Main Hoists — Heavy Duty Crushers Ore Stone Dredges Cutter Head Drive Jig Drive Screen Drive Elevators ‡Freight ‡Passenger Fans Cooling Towers Forced Draft Feeders Reciprocating Hammer Mills Machine Tools Punch Press & Gears Gear Driven ‡Notching Press — Belt Driven Plate Planers Mills — Rotary Type Rod Tumbling Barrels Metal Mills Forming Machines ‡Plate, Dryer & Scrubber Rolls (Reversing) Small Rolling Mill Drives ‡Table Conveyors (Reversing) Oil Industry ‡Oil Well Pumping Paper Mills Jordans Super Calender Pumps ‡Reciprocating — Double Acting — Single Cylinder ‡Reciprocating — Single Acting — 1 or 2 Cylinders Rubber Industry Mixer ‡Tire Building Machines ‡Tire & Tube Press Openers

‡Refer to Factory
©Drydock, Hammerhead, rotating and whirler — walker stationary or moving). Due to the nature of these crane drives, the following service factors are to be used for any duration of service. Main Hoist, 1.00; Auxiliary Hoist, 1.00; Boom (Luffing), 1.00; Rotating (Swing or Slew), 1.25; Trolling (Drive Wheels), 1.50.

HP=Horsepower transmitted
N=Revolutions per minute of reducer shaft
F=Factor for sprockets, pinions, sheaves, etc., shown below

For Single Chain Sprocket.....F=1
For Double Chain Sprocket or Spur Pinion...F=1-¼
For V-Belt Sheave.....F=1-½
For Flat Belt Pulley.....F=2-½

The maximum allowable overhung load is generally available from the gear reducer catalog, otherwise it can be obtained direct from the manufacturer. This cataloged overhung load rating is conservative. It takes into consideration the most severe situation wherein the direction of application of the imposed overhung load and direction of gearing reaction are the same or additive. The permissible overhung load capacities are figured on the basis of the loads being applied in a plane passing through the center of the effective length of the keyseat.

The change in the rating of the reducer as well as the permissible overhung load on the shafts is often overlooked when the output speeds are to be changed by the introduction of a V-belt drive to the high speed shaft. The AGMA has developed the classification of loads and operating conditions with recommended service factors for each case which should be used to check the suitability of any contemplated service change or load variation differing from the original use for which the equipment was selected, same as was done, presumably, at the time of the initial selection.

A copy of such a service factor sheet is shown in Figure 19.

Maintenance work is preventive. It should be based on the theory that "it is better to *keep* out of trouble than to *get* out of trouble." The maintenance problem is—to a large extent—a reflection of the forethought and talent applied in selecting the proper type of equipment at the outset.

DISCUSSION

PRESENTED BY

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E. J. WELLAUER, Assistant Chief Engineer, Materials and Research, Falk Corp., Milwaukee, Wis.

J. J. STOLZ, Assistant Vice President-Engineering, The Tool Steel Gear and Pinion Co., Cincinnati, Ohio.

William G. Bewley: The paper has dealt mainly with types of failure observed in gear sets where the shaft centers were fixed and remained constant due to the use of antifriction bearings, and shafts contained in housings where the centerlines remained parallel. These conditions, together with proper tooth profile, correct type and distribution of lubricant and inspections for conditions enumerated, should provide an ideal gear installation with all indications for long life of the same.

The American Gear Manufacturers Association deserves a great deal of credit for its constant research and furnishing us with various standards of profiles and proportions for different types of teeth such as 14-½ degree, 20 degree, stub etc.; also its means of identification of tooth failures and its engineered designs of gear reduction units.

In our particular mills and I believe in most of the older mills, the conditions enumerated above are seldom completely realized because:

1. The majority of our mill gears are on shafts mounted in babbitt or bronze bearings. As the bearings wear, the gears separate and the pitch circles operate on new centers. New centers are formed for each new increment of bearing wear. When the bearings have reached their allowable wear limit and are replaced, shaft centers return to their original locations. This process provides an ever changing condition of tooth mesh and wear. With plain bearings, one may wear more than another on the same shaft due to varying conditions of loading. This will produce an "out of parallel" condition and consequently uneven loading and wear across the gear face.
2. Many installations such as billet roller lines operate with cast gears, either spur or bevel. Even with extra care in moulding and casting, the finished gear will have irregular surfaces on faces and flanks of teeth. Some teeth may be thicker or thinner than others, depending on the amount of rapping of the pattern and the teeth may not be equally spaced around the pitch circle. All of these conditions tend to shorten the gear life. Allowances are made for inaccuracies in casting by making spaces between teeth wider than the tooth thickness. After the high spots are worn down, providing bearings and alignment are correctly adjusted, the tooth surfaces take a smooth contour and may be inspected for any of the signs of premature failure enumerated by the author.
3. The best designed teeth, no matter how well installed will not operate satisfactorily unless they are provided with the right amount of lubricant, properly applied and of the correct viscosity to maintain a continuous oil film between the mating teeth.

The author's views on cast one piece bases, for motors and speed reducers, are worthy of com-

ment. An important step in speed reducer installations is proper alignment of component parts. Any base, whether cast or fabricated must be of sufficiently rigid construction to prevent distortion and misalignment of motor and reducer. Bases should be grouted in and securely bolted down to concrete foundations or securely bolted to other supporting framework, before coupling halves are connected. The alignment then should be checked and any necessary adjustments made by shifting or shimming of the motor. This will prevent unnecessary heating and premature wear or failure of bearings, shafts or gears and thus add much to the life of the unit.

C. H. Burden: Mr. Johnson pointed out to us in his paper that it is certainly desirable to take into consideration shock loads and peak loads when selecting gearing that will be adequate for a given service. However, some times it happens that peak loads are encountered which had not been anticipated and these loads are enough to get us into trouble.

We recently made some changes on a rod mill which called for a number of existing gears to carry about double the load which they had been carrying for about 23 years of operation. Examination of these gears prior to the changes showed they were still in almost perfect condition and careful studies indicated that they should be capable of carrying this doubled load without failure. And, as it turned out, they did and still are successfully taking these doubled loads, although one gear did break unexpectedly early in the proceedings and it was apparent after the damage occurred that it had been subjected to something more like triple the previous loading for a reason that had not been foreseen.

The increased demands on these gears came about when we converted an existing continuous rod mill from two strand rolling to three strand rolling.

The mill, in operation since 1929, rolled two strands simultaneously in Stands 1 through 14 and then the strands diverged across two looping tables to two separate six-stand finishing mills, each taking one strand only and driven by its own 800-hp motor through six sets of spiral bevel gears.

To convert this mill to three stranding it was decided to bring three strands simultaneously up through Stands 1 to 14 and then alternately switch the center strand to first one finishing mill and then the other. This meant the rolling load would be increased fifty per cent in Stands 1 through 14, and doubled in each finishing mill during one half of the time, or whenever the center strand was in that particular mill. Power readings indicated that the driving motors would have sufficient power.

While an additional independent electrically driven pouring reel was installed for each finishing mill to take care of the added third strand, the two existing pouring reels for each mill remained as they were, driven through gearing and magnetic clutches from the drive shaft of Stand 20, thus being held in step with the mill. The actual stopping and restarting of each reel after each coil was completed was accomplished with a 50-hp motor with the magnetic clutch disengaged.

The speed of each of the finishing mills is controlled from a pulpit overlooking the looping tables by one operator so as to maintain the proper loop between Stand 14 and each finishing mill. Under the old two strand set-up, the variations in speed to control the loop were quite small and in general quite gradual.

However, when we started the mill up with this alternating third strand in the picture, the operator's life suddenly became much more complicated than before, particularly during the first weeks of breaking in to the new arrangement, and he was making sudden, frequent, and quite wide speed changes in the finishing mill in attempting to control the loops. Since the WR^2 of the two reels was substantial, the rapid acceleration and deceleration of the reels in unison with the mill imposed heavy additional loads on the Stand 20 drive gears, above and beyond that imposed by the added strand, and this was just too much for one of the gears and we stripped off half the teeth.

Fortunately we had planned to later eliminate this geared connection of the reels to the mill and convert them to electric drive, chiefly for reasons of flexibility in reel speed control, so we were able to complete this changeover during the few days it took to replace the broken gear and thus relieve the drive of this added severe loading that we had not counted on.

This relief was apparently sufficient for the replaced gear—and all the others too—they are still holding up and, we hope, will continue to do so.

W. E. Matthews: This paper was of much interest to me since we at the Sparrows Point Plant of Bethlehem Steel Co., are large users of gears and have practically every known type of gear used for power transmission, such as: (1) straight spurs, (2) single helical, (3) herringbones, both separated and continuous tooth, (4) straight tooth bevels, (5) zerol and spiral bevels, (6) conventional incut, tangential cut, and cone-type worm and wheels. They all have their purpose provided they are properly selected for the job they have to do.

Commenting directly on Mr. Johnson's paper, I must say the standard "off-the-shelf" or commercially available speed reducer does not come to my attention as often as a mill-drive unit. This is not necessarily because these units do not give trouble, but because the spare parts are more readily obtainable and because we can usually, in an emergency, make gears for such units in our shops, whereas, we cannot always make the larger mill-drive gears. Also, in defense of the manufacturers, let me say that in some cases when we do have trouble, it is our fault because of such conditions as a conveyor jamming or the like. You can be assured we make every attempt to correct these conditions.

Sometimes standard gear units are furnished with mill equipment by vendors who are highly competitive price-wise and we might get an under-designed unit for the job. However, it is the duty of the engineering department, master mechanic and lubricating engineer to be alert and see that we get gear units that will perform the job satisfactorily. If these units have standard AGMA ratings, we have to assume the manufacturer has built them in acordance with these standards. However, the AGMA standards do not cover every detail of the unit and some units have advantages over others for a particular application.

In my discussion, I will refrain from discussing the lubrication phase; first, because I am not a lubricating

engineer; second, too many of us are prone to blame lubrication for gear failures when it may not have been the basic cause; and third, in a large plant like the Sparrows Point Plant, the lubrication engineer and the master mechanics usually do a very good job on lubricating problems and the failures that are directly attributable to poor lubrication are few.

According to Mr. Johnson's statement, mill auxiliary drives are designed to give many years continuous trouble-free service provided that they are selected and maintained in accordance with AGMA recommendations. To my knowledge, there are few such units used as main mill drives or pinions. The main mill drives, in most cases, are made by the builders of the mill equipment, and are frequently built around their standards and facilities of manufacture. These builders have done a good job in the past, but with the increased loads and speeds imposed on mills today, they must improve their standards of design and manufacture.

With the knowledge and "know-how" available today, we should be able to eliminate a good many of our gear troubles. This should start with the original design by the engineer. He must consider the problems of the users as well as the problems of the manufacturer. It must be remembered that the only perfect gear is on the drawing board. Also, it must be noted that no improvement in the design of the tooth forms alone can outweigh the importance of careful and painstaking workmanship in both the production and the installation and mounting of the gears.

To improve the standards of design and manufacture, we must first know the causes of premature gear failures as well as the symptoms. To review briefly, some causes of premature gear failure are: poor original design of the gear itself, overload, improper installation, improper application, inadequate lubrication, poor selection of materials and defects in materials or workmanship.

Premature failure by overload (one of the most common causes) can result from a change in operating conditions such as a change in product rolled or production quotas, attempts to roll "cold" steel, or inadequate knowledge of applied loads as in the case of an auxiliary drive where the quick starting or stopping of the unit imposes heavy inertia loads. The symptoms of overload may be pitting, spalling, scoring and tooth breakage.

There are three alternate methods of attacking this overload problem: first, to reduce the load; second, to re-design the entire drive and replace it with gears of adequate proportions; and third, to employ superior materials and improved methods of manufacture and installation which will enable the replacement gears to carry the existing load. The first is very difficult to do in most cases as the mills are striving for all the tonnage they can get. The second is generally very expensive and the time required to make the new installation may be prohibitive. The third step, then, is the one that interests me most. There are several methods of attack in this step that are available which I will briefly list as follows:

1. Check starting and stopping inertia; see that electrical relays function as they are supposed to and be careful of the application of "across-the-line" starters.
2. Check materials used in the gears; even if the "beam" strength is adequate, the "wear-load capacity" might be too low. Today there are improved materials and processes that will add much to the life of gears such as the use of alloy grades of steel for case-hardening and heat-treating. Also, the new large type generative gear grinders make it possible to grind large hardened gears.
3. Check bearings and shafts by calculation to see if they are of adequate proportions to keep deflection to a minimum and that the bearing clearances and thrusts are satisfactory.
4. Check the design of the gear itself as to rim proportions, tooth profile, etc. It is often possible on heavily-loaded drives to incorporate modifications of the gear tooth to give better rolling action and to overcome inherent errors in machining such as tooth spacing and profile and also to add strength at the root of the tooth. The following are some of the modifications that can be made:
   a. Teeth generated with long and short addenda.
   b. Tip relief.
   c. Where design permits, you can use the principle of spread-center. For example, you might have a pair of mill pinions with eighteen teeth, one diametrical pitch, 20 degree pressure angle and you are having tooth breakage. To strengthen the tooth and use a more insensitive part of the involute, you would drop one tooth and generate seventeen teeth with the same outside diameter. This will automatically increase the pressure angle.

   To find operating pressure angle (A_2):

   Given: N_1—Number of teeth in pinion
   N_2—Number of teeth in gear
   A_1—Pressure angle of hob
   C —Center distance in in.
   P — Normal diametrical pitch of hob

   $$\text{Then } \cos A_2 = \frac{(N_1 + N_2) \cos A_1}{2C \times P}$$

   In the above example: N_1 equals N_2 equals 17
   A_1 equals 20 degrees
   C equals 18 in.
   P equals 1

   $$\cos A_2 = \frac{(17 + 17) \times 0.93969}{2 \times 18 \times 1} = 0.887$$

   A_2 equals 27-½ degrees

   All of these modifications can be done with the standard spur-geared hob or shaper-type generating cutters within limits except tip relief. Tip relief can be incorporated in the cutters when purchased.

I want to mention again that the mounting and assembly of gears is very important. At this point, I take exception to the statement in Mr. Johnson's paper that cast iron is superior to fabricated steel for gear housings. It is true that cast iron is a better vibration dampener than steel, but I would not say that a well-designed and stress-relieved fabricated or cast-steel housing or base plate would not serve equally as well as cast iron. On a number of recent mill installations, the gear housings have been made of cast steel to with-

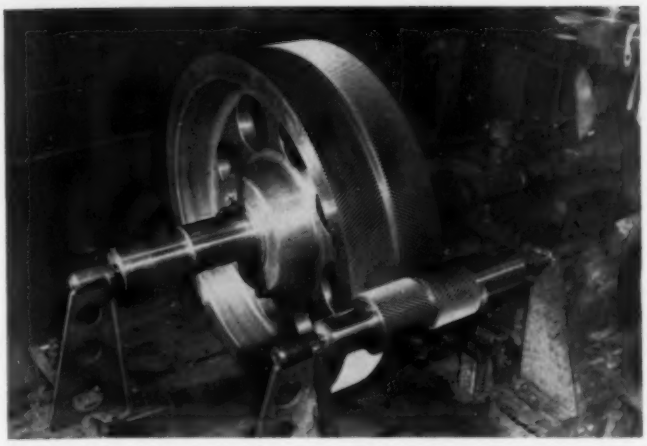


Figure 20 — These turbine reduction gears were made at the Sparrows Point plant of Bethlehem Steel.

stand abuse and permit ease of repair. There are also many fabricated steel housings in use which are giving good service.

There are a number of gear failures that can be attributed to poor engineering and bad processing. I have reference, for example, to trying to increase the wear hardness by flame-hardening. We have found this is a poor compromise for a case-hardened gear subject to heavy loads or shock in a steel plant. If time permitted, I could cite a number of cases of failures due to flame-hardening. There are applications where flame-hardened gears do a good job, such as the ring gear and pinion of a modern vertical boring mill table drive and other applications where the loads are light.

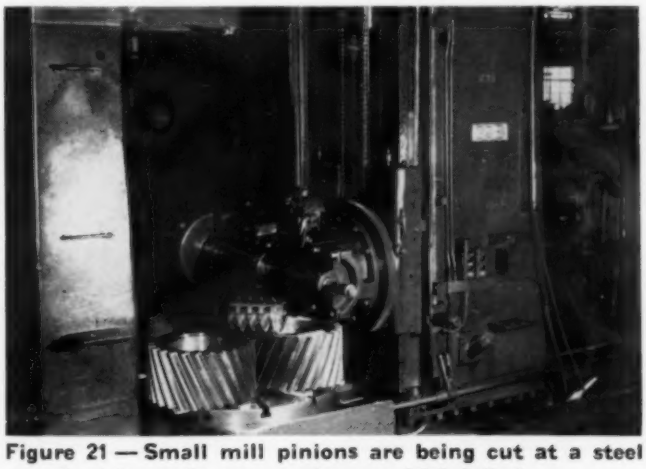


Figure 21 — Small mill pinions are being cut at a steel plant for replacement of gears which failed.

I would like to call to your attention two excellent papers that have been given before the "Association of Iron and Steel Engineers" which covered many phases of steel mill gearing that are very good for reference. They are: "Gearing for Steel Mill Auxiliaries and Cranes," by L. J. Collins 1947 Proceedings of the AISE and "Some Aspects of Selecting and Applying Gears for Rolling Mill Equipment," by E. C. Denne, previously referred to by the author.

The following figures illustrate some of the problems in gearing that I have discussed:

Figure 20 shows a new set of turbine reduction gears for a pump drive that we made in a hurry at Sparrows Point. This and similar gears for boiler fan drives have been made at Sparrows Point of improved materials

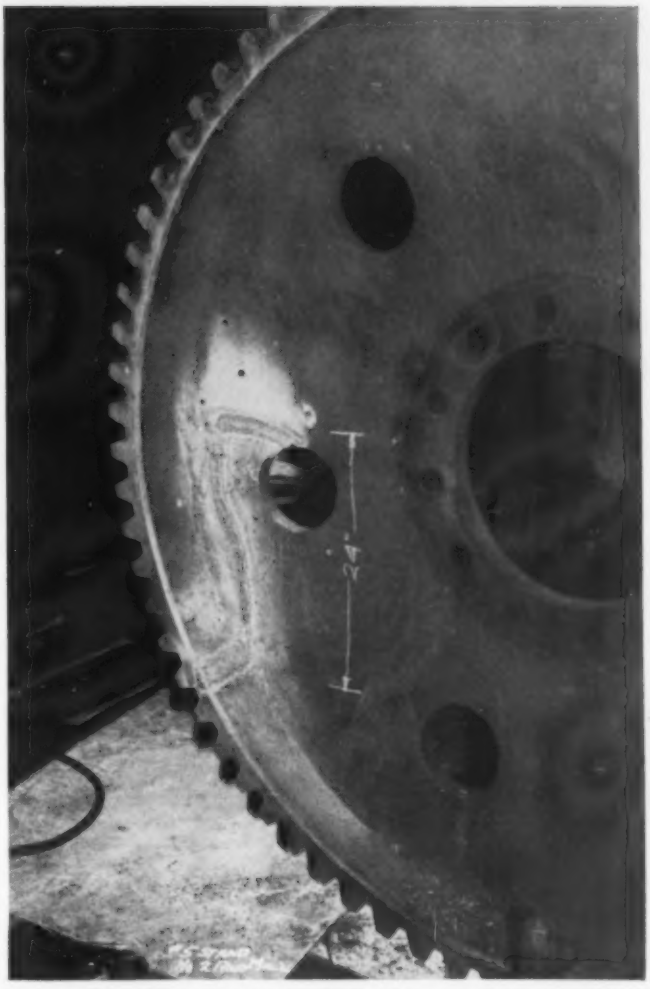


Figure 22 — Poor design caused failure of this gear which cracked under the rim.

to give better life, after the original ones failed because of poor materials being used. The replacement pinions have been made of Alloy steel, heat-treated to approximately 280 to 300 Brinell before cutting teeth.

Figure 21 shows a new pair of small pinions (13-¼ in.

Figure 23 — Detail of cracking in gear shown in Figure 22.

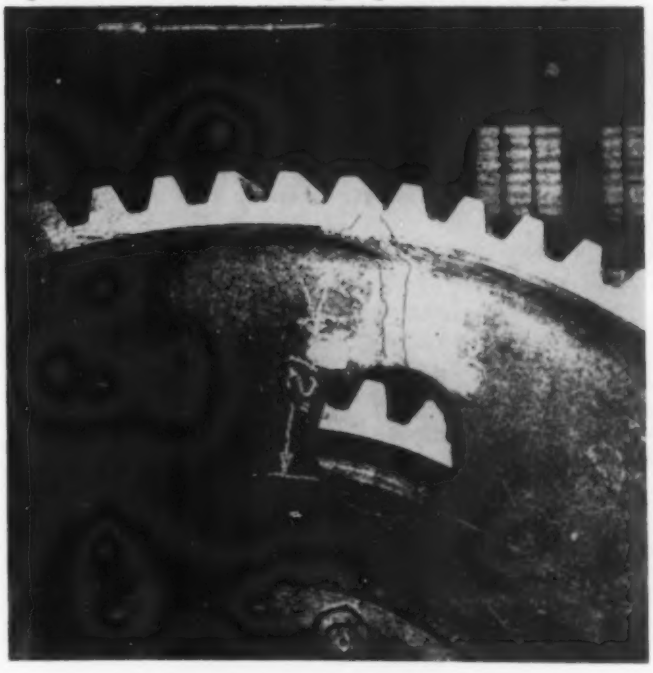


Figure 24 — Gear shown failed because of overload.

pitch diam) that we also made and the hob and the machine they were cut on. The original gears were case-hardened and had smaller teeth which failed under load. These replacements were made of alloy steel, heat-treated to 300 Brinell and cut with larger teeth. Recent pinions have been case-hardened and have ground teeth.

Figures 22 and 23 are two views of a helical gear mounted on a parallel shaft that failed because of poor design. The rim under the root of the tooth was too thin and the wedging action of the teeth caused the rim and web to crack, as can be seen from the welded area.

Figures 24, 25 and 26 show failures from overload. They represent spiral bevel gears used on the drive of one of our mills. In fairness to the designer, I want to say that we changed the mill operation after the original design of the drive and thus overloaded the gears. However, you will note the "bearing" was heavy on the heel of the tooth. Spiral bevel gears are difficult to keep in proper alignment and require very rigid mounting.

Figure 27 shows a large mill-drive gear. Note the pitting. The load was distributed uniformly over the face, but the load was too high for the hardness of the gear.

Figure 28 a case-hardened mill pinion failed due to loss of lubrication. The sprays became clogged and a section over-heated.

Figure 29 is a Blooming Mill pinion (forged steel) which failed after rolling 4,207,854 tons.

Figure 30 is a slabbing mill pinion (forged steel) — shows the wear experienced after rolling 12,966,295 tons.

Figure 31 is a slabbing mill pinion (cast steel) which shows wear after rolling 9,928,034 tons. Pinions were finally scrapped after rolling 11,500,000 tons.

Figures 30, 31 and 32 illustrate the wear and tooth breakage of slabbing and blooming mill pinions. You will note figures 31 and 32 show pinions for the same service but the forged steel pinions gave more life or tons rolled.

Figure 32 is a comparison of standard and modified tooth profiles. It shows an outline of the tooth forms that can be generated from a standard hob as mentioned previously in the discussion.

Walter J. Metcalf: I would like to discuss the inspection of gear cases, or as Mr. Johnson cited, the lack of

Figure 25 — Note failure at heel of tooth because bearing was heavily loaded at this location.

Figure 26 — Spiral bevel gears are hard to keep in line.

Figure 27 — Pitting on this mill drive gear occurred because of overloading.

Figure 28 — Failure here was due to lack of lubrication.

Figure 29 — This blooming mill pinion was made of forged steel.

inspection. One of the main problems is the designation of responsibility for inspection of each gear set. Field inspection of small gear cases in the steel industry amounts usually to a weekly checking of the oil level by one of the lubrication or maintenance men. That is, what normally happens until there is a failure, and then there are inspectors on all sides with enough handsight to explain what happened and why.

Our own plant is no exception, although recently, we have tried to install a regularly scheduled inspection of the more important small gear sets by our most

Figure 30 — Note wear which has occurred on this slabbing mill pinion.

Figure 31 — Pinion shown here was scrapped after rolling 11,500,000 tons.

experienced personnel. Still there are no records of any kind kept that you can refer to, to compare the gears, therefore this inspection is only as good as the inspector's memory.

The inspection has paid for itself in the few instances when something has been found. In one case, we found a small gear set in which one of the tapered roller bearings had split an outer race. We were without a spare, for this particular bearing, so we removed the inner race from the shaft, aligned it, poured a temporary babbitt bearing in its place and ran the set in this manner for several weeks until the regular bearings for the shaft arrived. During this time, the set was inspected

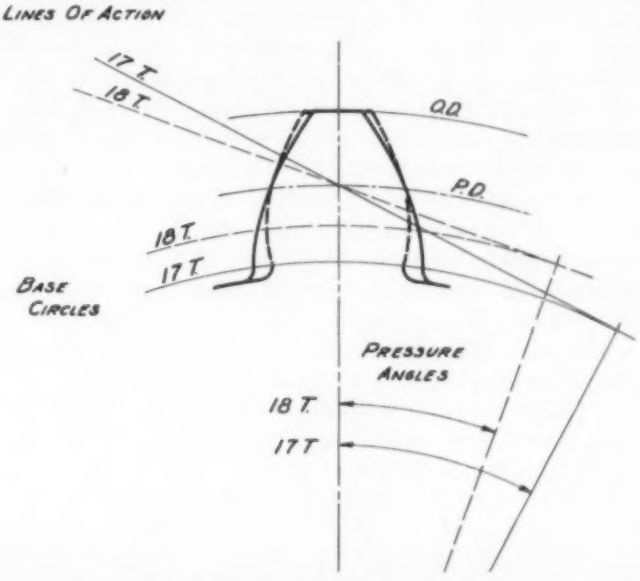


Figure 32 — Both teeth were generated with the same 20 degree hob. Note lack of undercut and stronger root structure on the modified profile.

daily, and by many people. At the end of the period we could not detect any undue wear or misalignment in the gears that might have been caused by this condition.

However, in most small plants, it is impractical and unnecessary to have an expert on gear failure causes. Inspection of the larger gear cases after they have been "run in," should be necessary only to see that the gear lubricant has not deteriorated or fallen below the oper-

ating level or that some mechanical condition has not caused thrust or misalignment. Therefore, only during the "run-in" period do most of these conditions discussed occur. During this time the services of the supplier should be available to the user to correct the conditions causing the gear tooth failure.

I will have to disagree in part with Mr. Johnson's remarks about specifications. From our own experiences, the majority of gear failures in the steel industry can be attributed to overloading. The equipment was probably designed properly for the conditions which existed at the time it was installed, or the conditions under which the designer was told that it would operate. Most of the heavy industry equipment is bought to last 20 to 30 years and during that time the loads involved and the uses of these machines are increased until they are doing work which the designer never intended or even dreamed they would do. The loads are increased gradually so that it is hardly noticeable to someone who sees it operate daily, but when the capacities are compared, the machine is probably operating only on the graces of a large factor of safety.

The causes and preventions of gear failures discussed here are the physical causes and what can be done to prevent them. The largest single cause of premature failures is the lack of some thought being given to the anticipated requirements, when the gears are being discussed with the designer. Therefore, this is the stage to apply your most effective prevention.

J. A. Bell: I agree with Mr. Matthews about the excessive loads being imposed over and above what the gears have been designed for, and that we cannot attribute failures to lack of lubrication in many cases. This is particularly true in respect to the larger mill pinions and gears which are readily accessible. The ones that usually give trouble are enclosed small drive units which are by-passed and neglected unless they are equipped for centralized lubrication.

A good example of this is our old mill table motor drives and line shaft gearing. In many cases these are exposed, with no covers, and very difficult to retain lubricant. With guards removed to make gears accessible, there is a tendency to allow gears to remain exposed to make it easier for the next application of grease. This means the end of the guard, and permits the gears to continue their operation with little or no lubricant. It is still my opinion that many premature gear failures can be attributed to lack of proper lubrication.

J. H. Hitchcock: I think that the principles which must be followed in order to avoid premature failure of gears can be stated quite simply. First, determine the duty cycle under which the particular gears will be operated. Second, select dimensions, materials and manufacturing processes which will produce gears adequate for the specified duty. Third, make sure that the gears are manufactured in accordance with the selected specifications. Fourth, install the gears properly and provide them with suitable lubricant. Fifth, make sure that the load applied in operation remains within the duty cycle which was determined in advance.

Although these principles can be stated readily, adherence to them in practice is sometimes difficult, particularly with respect to advance determination of the required duty cycle and adherence in practice to the duty cycle selected for design.

The necessity for knowing in advance the operating load to which the gears will be subjected cannot be emphasized too strongly, and I was very glad to hear Mr. Matthews introduce this important point. In the design of gear drives for rolling mills, we strive to incorporate a suitable factor of safety which will provide some margin for unexpected contingencies, but to avoid burdening the purchaser with the additional and unnecessary expense which would necessarily accompany a larger safety factor. In the absence of exact knowledge of the load to be applied, it is necessary to employ a larger factor which, in that case, I would describe not as a factor of safety, but as a factor of ignorance. I think you will agree that it is preferable to know the facts in advance, by measurement if possible, so that gears of adequate but not excessive capacity can be designed intelligently.

Adherence in practice to the load specified for design must be complete if premature gear failures are to be avoided with certainty. Mr. Matthews mentioned one instance in which a gear failure resulted from a marked change in operating practice; in this case the new applied load exceeded the design capacity by a wide margin. Other similar instances could be cited, and perhaps the advantages gained by the modified practices are sufficient to justify economically the delay and expense of replacing gears which have failed. However, the adoption of a modified practice which produces gear loads exceeding the design capacity should be undertaken only as a calculated risk, with full knowledge that gear failure may result.

I applaud Mr. Matthews' comments regarding the improvements which have appeared in recent years with respect to the heat treatment and manufacturing processes employed for rolling mill drive gears. In contrast to high speed ship propulsion gears, the tolerances for rolling mill drive gears previously have been relatively crude, principally because of the limitations of existing manufacturing equipment. There is now a decided trend toward materials and heat treating processes which provide superior mechanical properties and manufacturing methods which provide greatly increased accuracy; considerable increase of gear capacity is available because of these developments.

Several earlier speakers have suggested that selection of lubricants is not a critical matter in the performance of well designed gear drives, and I share this view. For rolling mill gear drives we specify mineral oils having an extreme pressure additive of the lead-naphthenate type, with the expectation that the mild extreme pressure properties which such lubricants possess will prevent localized welding or spalling while the minor irregularities remaining after machining are being removed during the early period of operation. Aside from this property of the extreme pressure lubricant, which becomes less essential with improved accuracy of machining, we regard extreme pressure additives in gear drives as aspirin pills, designed to treat the symptoms of a malady which had its origin either in design or in overload resulting from revision of operating practice.

A. E. Cichelli: I thoroughly enjoyed this entire evening, particularly since most of the speakers were reluctant to blame lubrication for their troubles. We are

not always sure of getting that kind of treatment. Despite the completeness of the papers, there is one question that bothers us.

We have two separate mills in which we experienced considerable pitting on the pinions. In one mill an extreme pressure oil was used; in another a straight mineral oil was used. As is our practice, we immediately set about to determine whether or not these pinions were overloaded. We wonder what that actually means. The conventional practice is to go back to AGMA procedure. AGMA has provided engineers with all kinds of formulae for determining whether a given gear set is overloaded. Formulae are provided for evaluating the wear-limit. Another equation is given for determining the beam-strength, and finally, the actual dynamic load can be calculated for a particular drive—dynamic load being the addition of the actual horsepower transmitted, plus loading due to tooth imperfection. In each case the pitting somehow took place. But the dynamic load was under the wear-limit—not by much, but it was under it, nevertheless. According to AGMA, then, these teeth were designed adequately to carry the load, and should not have worn out or pitted.

Now, I would like to know what the differential should be between the dynamic, and the wear-limit and/or the beam strength. What do you design for? Is it 5 or 10 or 50 or 100 per cent or what is it. We would certainly like to know, because from experience with a 10 per cent differential, whether mineral or extreme pressure oil, our pinions still pit and wear out.

J. Clinton Weight: From Mr. Hitchcock's remarks in relation to the "aspirin" it would seem to me you should give consideration to the straight mineral oil, first, reserving the extreme pressure as the cure for the headache when it actually occurs. And there is a parallel to that in considering marine applications. Vessels of 10,000 to 45,000-ton displacement certainly are comparable applications to rolling mills, particularly in heavy seas, when I am told the propellers come out of the water, and so on—but it is more or less common practice in marine circles to use straight mineral oil in marine engineering. I would like to hear somebody further elaborate on that, plus the pitting in the bearings in the form of lapping, after grouting in position, particularly on the heavier drives.

H. J. Leaver: I was interested in hearing the comments of the gentlemen from Sparrows Point about field maintenance problems with gears. Regardless of what equipment is designed for, the people out at the mill have to put up with a condition where they require more tons out of the equipment and they do not have time to take it down or replace it. You have to make it go.

This leads up to this question of extreme pressure vs the straight mineral lubricants. To cite a personal experience parallel to what the gentleman had in his mill design. At American Steel and Wire Company we had a mill, previously designed for two line rolling, and put in three lines. The mill had operated with straight mineral oil for twenty years, and the gears were fine. We added the third line product and within six months the gears started to spall a lot and then we changed to an extreme pressure lubricant. The gear spalling immediately stopped, and the gears smoothed out nicely.

Then another problem came into the picture. The lubricant that was proper for the gears was not proper for the bearings being serviced by the same lubricant. It required a lot of experimenting before we found a lubricant that would hit the half-way point of adequate protection to the gears, and still protect the bearings —because of the variation in viscosity needed for the two different jobs. This was finally found, and the problem solved.

There was another question raised here when someone made a comment that extreme pressure oils are to be treated only as an aspirin tablet that you use when you are in a jam and it offers the only way out.

Recently, I helped design a new rod mill for Jones & Laughlin Steel Corp. I had exactly that same idea in mind. I talked to a fellow that I think everybody knows—one of the best steel mill gear designers in the business. He said: "If I design you a mill so that the gears in it will work satisfactorily, with the tooth loading that they would require with mineral oil, your company is going to pay a lot more money for that mill." He said: "Under no circumstances would we think of designing with that thought in mind. It would not be economically sound."

The mill was designed for a regular extreme pressure lubricant, and as it is now in operation, it seems to be working along all right. Evidently, it was the answer to the problem.

When you start talking about this question of designing for mineral oils, you have to keep in mind that the people that sell the equipment, often do not only deal with engineers—they deal with purchasing agents, and to a purchasing agent, a gear is a "gear," big or little. One costs two dollars; the other costs ten. So he will always take the two dollar gear. It is not a problem that you can treat lightly. It is a problem that requires consideration not only by your engineering staffs, but somewhere along the line you have to develop master salesmen to convince people to put adequate money into good material.

L. F. Coffin: Many steel mills could profit by applying engineering knowledge now available for use in the manufacture of large and small mill drives. We should not accept offered gearing without checking to make sure it falls within accepted engineering practice. This should be done in a systematic manner.

E. J. Wellauer: Mr. Johnson is to be commended for adequately pointing out the necessity of selecting proper service factors for units to be used for the usual steel mill requirements. It is naturally to be expected that a unit selection of adequate size to meet the service conditions is one of the surest means of guarding against premature failure and assuring long life with a very minimum of maintenance.

The emphasis also placed upon the improved performance of high pressure angles should be noted carefully. Our company pioneered in the initial research which fully demonstrated the adequacy on this conclusion and resulted in the development of our improved tooth form.

Mr. Johnson also made several remarks which tended to indicate that changes in gear proportions, surface finishes etc. can result in thick film lubrication of gearing. This is not a fact, since research has definitely in-

dicated that thick film lubrication, such as found in sleeve bearings, does not occur in gearing. The actual condition is solid contact probably modified very slightly by hydro-dynamic film formation. This is not a great disadvantage because it explains why gear mesh losses seldom range more than ½ per cent of the transmitted load.

One of the other commentators remarked about the advantageous load capacity of hardened gears as applied to durability ratings. Actually, careful consideration must be given the resulting tooth contact secured with hardened gears. Excessive distortion can nullify much of the expected increase in rating due to higher hardness. The gear tooth beam strength is particularly sensitive to load concentrations and must be critically reviewed. Finally, the increased ratings of harder gear sets must be economically justified when compared to that of the more normal hardness levels generally used.

J. J. Stolz: There are many causes of gear failure. I would like to mention a few of the more common causes that may occasionally be overlooked—lubrication, that the author so ably points out, bad bearings, misalignment, and overloading.

In recent years it has been noted that a fair percentage of gear failures are traceable to overloading. Formerly gearing lasted many years, now on the same drive gears give trouble. Upon investigation it is found that greater capacity motors have been installed with little or no thought being given to the gearing or other parts. The method assembly and the amount of interference in the fit can also cause gear failure through stress concentration at the keyway section, particularly on pinions.

Failures caused by pitting, scoring, etc., I believe, can be cured by raising the hardness and using better steels. For example, on a large slab mill the drive pinions were of a good quality, heat treated steel. Pitting and scoring caused total destruction in a period of nine months. Carburized and hardened pinions were substituted, and at present, after 24 months of service, the pinions are in good shape with possibly another 24 months' life still remaining. Another case on slab mill drive pinions, flame hardened herringbones gave only six months' wear life. Again, carburized and hardened pinions were substituted with wear life again extending to years of service. These pinions are also still in service.

It is particularly gratifying to note, both in Mr. Johnson's paper and Mr. Matthews' discussion, the trend in thinking and the fact that cognizance is being taken of the advantage of 20 degree pressure angle gearing, both standard depth and the long and short addendum variation. Certainly the gear makers generally prefer 20 degrees pressure angle gearing. Consideration should be given to the long and short addendum system when pinions get below 18 teeth. The long and sort addendum system on low numbers of teeth practically eliminate the undercutting caused by true involute generation, and will not only give considerably greater strength, but will give much smoother rolling action with less vibration resulting. I believe that a good rule to follow in the selection of long and short addendum gearing is based on the ratio of the set. When the ratio is 3:1 or gerater, then the selection of long and short addendum gears and pinions becomes ideal. The thinking behind this is that on large ratios the pinion is generally small in number of teeth, and should, therefore, be long addendum to eliminate the undercutting.

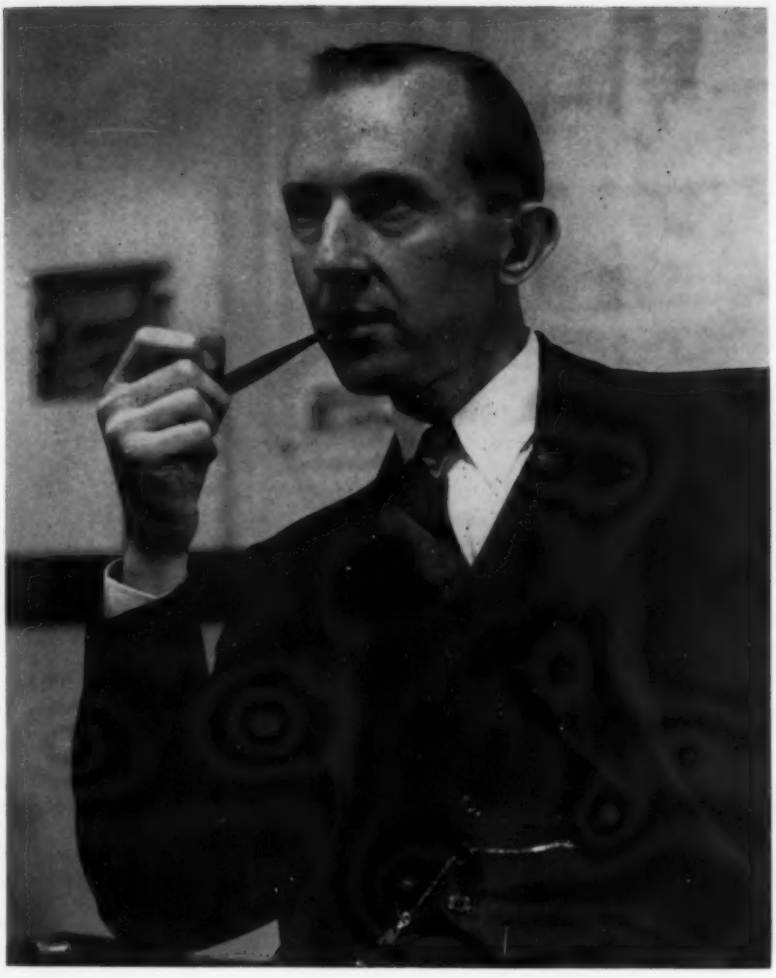
Just recently I had the opportunity of visiting England and noted some of the work that has been done by the Motor Industry Research Association. Their studies cover pitting gears. After considerable work the conclusions reached were that case hardened gears had approximately 70 per cent greater load carrying capacity and resistance to pitting than the through hardened steel gears.

FARRINGTON-AISE FUND ESTABLISHED

▲AT the spring meeting in Buffalo on May 17, the Board of Directors of the AISE voted to give Rose Polytechnic Institute at Terre Haute, Ind. the sum of $1500 which will be known as the Farrington-AISE Fund. This fund will be used by the school for scholarships for needy engineering students of high standing or will be used for the purchase of equipment needed by the school.

It was further decided that this gift would be considered each year by the AISE Board of Directors and, if finances permit, will be duplicated each year. This award was established as a tribute to James Farrington, founder and first president of the AISE. Mr. Farrington is an electrical engineering graduate of Rose Polytechnic Institute in the class of 1896 and is one of its outstanding alumni. He received an M.S. in Electrical Engineering in 1900. Mr. Farrington, who is still active in the steel industry, was one of the pioneers in the electrification of the steel industry and in the application of electric drives and control for steel plant operations. His contributions and those of the organization which he founded have been a very important factor in making the steel plants a better place to work and in enabling production of better steel at more economical costs.

Mr. F. L. Wilkinson, Jr., president of Rose Polytechnic Institute, has stated that they expect the fund to be divided this year between two purposes, one part will probably be used for the establishment of one full term scholarship which will be known as Farrington-AISE scholarship, and the remainder will be used for the purchase of equipment for the laboratories. This will definitely be decided by their Board of Managers at their October meeting.



An Invitation to the

AISE ANNUAL CONVENTION

On September 28, 29, 30 and October 1, the Association of Iron and Steel Engineers will hold its 1953 convention at the Wm. Penn Hotel in Pittsburgh. There will be no Iron and Steel Exposition inasmuch as this is an off year in our exposition schedule.

The technical sessions, however, present papers of very broad interests. Leading authorities on steel plant equipment and operation will discuss problems vital to the industry.

We know that everyone attending these sessions will benefit from the discussions. The meetings are open to anyone connected with the iron and steel and allied industries. The men of the industry are cordially invited to attend.

JOHN L. YOUNG
President, AISE

Program

ASSOCIATION OF IRON AND STEEL ENGINEERS

1953 CONVENTION

WILLIAM PENN HOTEL

PITTSBURGH, PENNSYLVANIA

September 28, 29, 30, October 1

Monday, September 28

9:00 am — REGISTRATION — Fort Duquesne Room

9:15 am — BUSINESS MEETING — Urban Room

Conducted by President John L. Young

9:30 am — OPERATING PRACTICE SESSION— Monongahela Room

Chairmen: George Greene, Assistant General Manager, Bethlehem Steel Co., Johnstown, Pa.

P. E. Thomas, Assistant General Superintendent, United States Steel Corp., Gary, Ind.

"The Impact of Technological Developments in the Light Flat Rolled Steel Process on the Consuming Industries," by William T. Hogan, S. J., Professor of Economics, Fordham University, New York, N. Y.

"Scrap Preparation and Scrap Contamination," by Robert F. Kuhnlein, Superintendent of Construction, Sheffield Steel Corp., Kansas City, Mo.

"Modern Underground Coal Mining," by R. H. Knapp, Chief Engineer—Coal, United States Steel Corp., Pittsburgh, Pa.

9:30 am — ELECTRICAL SESSION — Urban Room

Chairmen: K. L. Johannsen, Division Superintendent Maintenance and Utilities, United States Steel Corp., Morrisville, Pa.

Robert S. Bogar, Assistant Electrical Superintendent, Bethlehem Steel Co., Johnstown, Pa.

"Grounded versus Ungrounded Low-Voltage A-C Systems," by H. B. Thacker, Distribution Engineer, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

"Cathodic Protection of Mill Grounding Systems," by J. F. Headlee, Electrical Design Engineer, Construction Engineering Bureau, United States Steel Corp., Fairless Hills, Pa.

"Integrated Electrical Equipment for Blast Furnaces," by C. P. Hamilton, Application Engineer, General Electric Co., Schenectady, N. Y.

2:00 pm — MECHANICAL SESSION — Monongahela Room

Chairmen: F. E. Robinson, Assistant Division Engineer, American Steel & Wire Div., United States Steel Corp., Cleveland, Ohio.

E. C. Hite, Assistant Superintendent Maintenance, Timken Roller Bearing Company, Canton, Ohio.

"Foundation Design for Iron and Steel Plants," by G. S. Richardson, Consulting Engineer, Pittsburgh, Pa.

"Water Supply for Steel Plants," by Ross Nebolsine, President, Hydrotechnic Corp., New York, N. Y.

"Ultrasonics in Maintenance Planning and Product Quality Control," by R. L. Rectenwald, President, Maintenance Engineering Corp., Pittsburgh, Pa.

2:00 pm — OPEN HEARTH SESSION — Urban Room

Chairmen: G. H. Krapf, Technical Assistant — Fuel and Power Operations—Steel Div., United States Steel Corp., Pittsburgh, Pa.

E. H. Cauger, Chief Combustion Engineer, Wheeling Steel Corp., Steubenville, Ohio.

"Improved Cleaning Techniques for Open Hearth Checkers," by J. J. Enochs, Sales Engineer, Dowell, Inc., Wilmington, Del. and Reece Kincaid, Sales Engineer, Dowell, Inc., Chicago Heights, Ill.

"Cleaning of Open Hearth Checkers and Sewers During Operation," by Robert M. Jordan, Assistant Superintendent No. 3 Open Hearth, Bethlehem Steel Co., Lackawanna, N. Y.

"Republic's New Open Hearth Furnaces at Cleveland," by E. C. McDonald, Superintendent, Combustion Dept., Republic Steel Corp., Cleveland, Ohio.

"New Open Hearth Furnaces at Stelco," by E. T. W. Bailey, Chief Combustion Engineer, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

6:00 pm — INSPECTION — U. S. Steel Office Building — Get tickets at Registration Desk.

9:30 pm — PRESIDENT'S RECEPTION AND INFORMAL DANCE — Urban Room

AISE members and guests. No admission charge.

Tuesday, September 29

9:00 am — BLAST FURNACE REFRACTORIES SESSION — Urban Room

Chairmen: C. G. Hogberg, Assistant Chairman — Blast Furnace Committee, United States Steel Corp., Pittsburgh, Pa.

J. A. Bell, Chief Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Temperature Distribution in the Hearths of Blast Furnaces," by Professor V. Paschkis, Technical Director, and Taghi Mirsepassi, Research Engineer, Heat and Mass Flow Analyzer Laboratory, Columbia University, New York, N. Y.

"Trends in Blast Furnace Linings," by Hobart M. Kraner, Ceramic Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Bricklaying as a Factor in the Performance of Blast Furnace Linings," by W. S. Debenham, Research Associate, Research and Development, United States Steel Corp., Pittsburgh, Pa.

9:00 am — LUBRICATION SESSION — Monongahela Room

Chairmen: C. A. Bailey, Lubrication Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

Andrew E. Cichelli, Lubrication Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Activated Alumina for the Maintenance of Gas Engine Crankcase Oils," by Lowrie B. Sargent, Jr., Assistant Chief, and E. M. Kipp, Chief, Lubricants Division, Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa.

"Oilless Bearings — Their Place in Industry," by Charles D. Spadone, Vice President, Spadone-Alfa Corp., New York, N. Y.

"Application of Bronze Bearing Alloys," by James L. Duchene, Sales Representative, National Bearing Division, American Brake Shoe Co., Pittsburgh, Pa.

"Laminated Fabric Bearing Materials," by Richard L. Berry, Manager, A-B-K Sales, American Brakeblok Division, American Brake Shoe Co., Detroit, Mich.

2:00 pm — MATERIALS HANDLING SESSION — Monongahela Room

Chairmen: Carleton Lord, Materials Handling Engineer, United States Steel Corp., Pittsburgh, Pa.

M. D. Ayers, Chief Engineer, Wheeling Steel Corp., Wheeling, West Va.

"Imported Ore Handling — Machines and Practices," by Erle M. Hays, Sales Engineer, Crane & Bridge Dept., Engineering Works Division., Dravo Corp., Pittsburgh, Pa.

"Intraplant Handling of Round Billets and Pipe with Special Automotive Equipment," by J. D. Tyson, Superintendent, Warehousing and Shipping Dept., National Tube Division, United States Steel Corp., Lorain, Ohio.

"Application of Self-Centering Rolls for Strip Processing Lines," by E. T. Lorig, Chief Development Engineer, United States Steel Corp., Pittsburgh, Pa.

2:00 pm — ELECTRICAL SESSION — Urban Room

Chairmen: D. C. McCrady, Superintendent Electrical Dept., Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada.

R. T. Lucas, Electrical Superintendent, Weirton Steel Co., Weirton, West Va.

"System Engineering for Continuous Strip Processing Line," by J. S. Apperson, Steel Mill Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

"Temper Mill Control," by George P. Dirth, Electrical Engineer, Granite City Steel Co., Granite City, Ill.

"Estimating Motor Room Installation Costs," by Wray Dudley, Chief Consulting Engineer, Patterson-Emerson-Comstock, Inc., Pittsburgh, Pa.

"Crane Power Limit Switches," by Robert W. Graham, Superintendent Electrical Dept., Bethlehem Steel Co., Lackawanna, N. Y.

6:00 pm — OLD TIMERS DINNER — Urban Room

Wednesday, September 30

9:00 am — ELECTRIC FURNACE SESSION — Urban Room

Chairmen: A. K. Blough, Superintendent No. 2 and 3 Melt Shops, Republic Steel Corp., Canton, Ohio.

Robert Sergeson, Chief Metallurgical Engineer, Rotary Electric Steel Co., Detroit, Mich.

"Growth Possibilities of Electric Furnace Carbon Steel," by W. C. Wheeler, Management Consultant, New York, N. Y.

"Cost Comparisons of the Open Hearth and Electric Furnace," by David D. Moore, Assistant Supervisor, Engineering Economics Division, Battelle Memorial Institute, Columbus, Ohio.

"The Future of Large Electric Furnaces Compared to Modern Open Hearths," by Frank W. Brooke, Pittsburgh, Pa.

9:00 am — ROLLING MILL SESSION — Monongahela Room

Chairmen: Alex Montgomery, Jr., Assistant to Vice President—Rolling, United States Steel Corp., Pittsburgh, Pa.

J. N. Imel, Superintendent Sheet and Strip Dept., Jones and Laughlin Steel Corp., Pittsburgh, Pa.

"The Direct Rolling of Carbon Steel Ingots to Plates on Three High and Four High Plate Mills," by Robert C. McMichael, Supervisor 112-120-in. Mills, Lukens Steel Co., Coatesville, Pa.

"Recent Advancement in Continuous Butt Weld and Induction Weld Pipe Mills," by William Rodder, Vice President Engineering, Aetna-Standard Engineering Co., Pittsburgh, Pa.

"Temperature Gradients and Stresses in Iron Work Rolls," by Charles F. Peck, Jr., Assistant Professor, Juan M. Bonetti, Pre-Doctoral Fellow, and Frederick T. Mavis, Professor and Head, Dept. of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

2:00 pm — COMBUSTION SESSION — Monongahela Room

Chairmen: G. J. Gockstetter, District Combustion Engineer, Republic Steel Corp., Chicago, Ill.

A. F. Kritscher, Assistant Chief Engineer, Process Development, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

" Progress in the Development and Application of Metallic Recuperators in the Steel Industry," by E. A. Vierow, Superintendent, Fuel and Power Dept., Youngstown Sheet & Tube Co., Youngstown, Ohio.

"New Soaking Pit Facilities at Ford Motor Co. Steel Division," by B. D. Barns, Supervisor, and H. E. Raaflaub, Senior Fuel & Utilities Engineer, Fuel & Utilities Dept., Steel Div., Ford Motor Co., Dearborn, Mich.

"Heat Processing in Industry — Facts and Figures," by Frederic O. Hess, President, Selas Corp. of America, Philadelphia, Pa.

2:00 pm — ELECTRICAL SESSION — Urban Room

Chairmen: F. H. Wickline, Electrical Engineer, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

George A. Kaufman, Chief Electrical Engineer, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

"Modern Arc Furnace Equipment and Practices," by E. H. Browning, Steel Mill Engineer, Metal Working Section, Westinghouse Electric Corp., East Pittsburgh, Pa.

"The Determination of Optimum Current in an Arc Furnace," by W. E. Schwabe, Research Engineer, National Carbon Research Laboratories, Cleveland, Ohio.

"Problems in Supplying Power to Electric Furnaces," by George E. Duerr, Industrial Sales Manager, West Penn Power Co., Pittsburgh, Pa.

7:00 pm — FORMAL DINNER — Ball Room

10:00 pm — DANCE — Urban Room

AISE members and guests. No admission charge.

Thursday, October 1

9:00 am — COMBUSTION SESSION — Urban Room

Chairmen: F. B. Bevelheimer, Power and Fuel Engineer, Ford Motor Co., Dearborn, Mich.

R. A. Lambert, Superintendent Steam and Combustion, Jones and Laughlin Steel Corp., Pittsburgh, Pa.

"Studies on Provision and Use of Oxygen in Steel Plants," by Glen O. Carter, Partner, Percival R. Moses & Associates, Consulting Engineers, New York, N. Y.

"Use of Plastic, Castable, and Gunning Materials in Soaking Pits," by W. D. Rees, Superintendent, Bar and Blooming Mill, Sharon Steel Corp., Lowellville, Ohio.

"Combination Fuel Firing for High Pressure Boilers," by C. J. Webster, Fuel Engineer, National Tube Division, United States Steel Corp., McKeesport, Pa.

9:00 am — LUBRICATION SESSION — Monongahela Room

Chairmen: D. E. Whitehead, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.

W. M. Schuck, Lubrication Engineer, Armco Steel Corp., Middletown, Ohio.

"Factors Affecting the Performance of High Temperature Greases," by Eldon L. Armstrong, Research Associate, Socony-Vacuum Laboratories, Technical Service Dept., Brooklyn, N. Y.

"Pumpability of Steel Mill Grease," by Joseph S. Aarons, Lubricants Chemist, National Tube Div., United States Steel Corp., Pittsburgh, Pa., Richard G. Warren, Lubrication Engineer, United States Steel Corp., Homestead, Pa., and J. J. Seaton, Laboratory Technician, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

"Steel Mill Lubrication Problems," by A. C. Keiser, Jr., Supervising Lubrication Engineer, The Texas Co., Birmingham, Ala.; E. E. Perso, Supervising Lubrication Engineer, The Texas Co., Los Angeles, Calif.; W. H. Mandy, Engineering Representative, The Texas Co., New York, N. Y.; and M. S. Clark, Chemist, Technical and Research Div., The Texas Co., New York, N. Y.

1:30 pm — INSPECTION TRIP TO PITTSBURGH WORKS, JONES & LAUGHLIN STEEL CORP.

This trip will include the open hearth shop, and blooming mill, as well as the strip mill.

Ladies Program

MONDAY, September 28

9:00 am — Ladies Registration — Parlors E - F, William Penn Hotel
3:00 pm — Welcome Party — Women's City Club, William Penn Hotel
6:00 pm — Inspection — New U. S. Steel Office Building — Get tickets at Registration Desk
9:30 pm — President's Reception and Informal Dance — Urban Room, William Penn Hotel

TUESDAY, September 29

12:30 pm — Luncheon — Pittsburgh Field Club — Buses will leave William Penn Hotel at 11:00 am. (Ladies meet in Parlors E - F, William Penn Hotel)

WEDNESDAY, September 30

7:00 pm — Formal Dinner — Ballroom, William Penn Hotel
10:00 pm — Dance — Urban Room, William Penn Hotel

Honorary Chairwoman — Mrs. J. L. Young *General Chairwoman* — Mrs. F. S. Bloom
Vice Chairwoman — Mrs. C. H. Williams

To partially cover costs, a flat registration charge of $5.00 will be made which will cover all ladies' activities except the formal dinner on Wednesday evening. This must be paid on registering, when tickets will be issued for these events.

Chairmen
1953 AISE Annual Convention

GEORGE GREENE

P. E. THOMAS

K. L. JOHANNSEN

ROBERT S. BOGAR

F. E. ROBINSON

E. C. HITE

G. H. KRAPF

E. H. CAUGER

C. G. HOGBERG

J. A. BELL

C. A. BAILEY

A. E. CICHELLI

CARLETON LORD

M. D. AYERS

D. C. McCRADY

R. T. LUCAS

A. K. BLOUGH

R. SERGESON

A. MONTGOMERY JR.

J. N. IMEL

G. J. GOCKSETTER

A. F. KRITSCHER

G. A. KAUFMAN

F. H. WICKLINE

F. B. BEVELHEIMER

R. A. LAMBERT

D. E. WHITEHEAD

W. M. SCHUCK

Abstracts of Technical Papers

To be presented at Technical Sessions of

AISE ANNUAL CONVENTION

WILLIAM PENN HOTEL

PITTSBURGH, PA.

SEPTEMBER 28, 29, 30, OCTOBER 1, 1953

"THE IMPACT OF TECHNOLOGICAL DEVELOPMENTS IN THE LIGHT FLAT ROLLED STEEL PROCESS ON THE CONSUMING INDUSTRIES"

by WILLIAM T. HOGAN, S. J., Professor of Economics, Fordham University, New York, N. Y.

W. T. HOGAN, S. J.

▲ FOR a number of years, competition and the need for improved products in the industries that use steel have caused many problems for the steel makers. This is particularly true in the light flat rolled segment of the industry.

In the automotive industry, the designers have often gone to extremes to make their models more attractive and thus more salable. This policy required constantly improved steel sheets. Difficulties which arose in the production and use of these sheets were solved by technological advances in steelmaking, as well as the improved machine tools and presses in the automotive industry.

In the manufacture of electrical equipment, the desire for a more efficient product has inspired both the manufacturers of the equipment and the steel producers, to work toward improved silicon sheets. The same is true in the manufacture and use of galvanized sheets where superior zinc coatings have been developed.

This paper discusses some recent developments in the making of steel sheets that have virtually eliminated difficulties heretofore encountered by the consuming industries in their use. Two such developments will be covered, and a third example will consider a technological advance in the automobile industry in the use of steel sheets.

The three instances to be treated in detail will be:

1. The production of grain oriented steel for electrical sheets.
2. The development of continuous galvanizing.
3. The notched automobile front fender.

The second section of the paper treats of the use of tinplate by the can makers. Here again, competition with other forms of containers, such as glass and paper, has spurred the can makers to improve their product so that its use could be extended. They were aided in this by two revolutionary changes in the production of tinplate, namely, the use of cold reduced steel and electrolytic plating. Both innovations have enabled the can companies to turn out a product suitable for a variety of uses.

At the present time some new problems are facing the can makers, and it is hoped they will be resolved through such technological developments in the steel industry as continuous annealing and the application of differential coatings on electrolytic plate.

These recent technological changes are discussed as possible solutions to the can makers' problems.

"SCRAP PREPARATION AND SCRAP CONTAMINATION"

by ROBERT F. KUHNLEIN, Superintendent of Construction, Sheffield Steel Corp., Kansas City, Mo.

R. F. KUHNLEIN

▲ SCRAP is truly a remarkable and glamorous industry.

It takes the waste or by-products of the manufacturing plants, the railroads, the home — in fact, every place where iron and steel are used and transmuted into a vital raw material. It is a commodity that is never purposely produced — merely happens, but which during the year 1951 totaled over 68,000,000 gross tons of which 33,800,000 gross tons were purchased scrap.

There are two main classifications of scrap used in steel making — home scrap and purchased scrap. Home scrap, as the name implies, is that produced by the steel industry itself and is the crop ends of blooms, slabs, billets, bars and scrap from its finishing facilities. This scrap is almost always used at the point of origin. Purchased scrap is produced wherever steel is used and is collected, sorted, and prepared by scrap dealers for distribution to the various mills. This includes scrap from industrial or factory sources, railroads, farms, auto wrecking yards, demolition of old structures, ships, etc. The three main sources of foreign scrap — metal working factories, auto wrecking yards and railroads — accounted for, in round numbers, about 18,000,000 tons of purchased scrap in 1951, leaving 16,000,000 tons to be ascribed to farms, demolition, agencies of the national, state and local governments, public utilities, ship breaking, detinning and other sources. In round numbers, farms may have yielded about 3,000,000 tons, detinning 500,000 tons, ship breaking 400,000 tons and governmental agencies exclusive of overseas material 500,000 tons.

There are problems with both types of scrap but since it is possible to control more closely any contaminated scrap that is produced in one's own plants, it is the foreign scrap that is discussed in this paper.

Foreign scrap has been broken down by the Department of Commerce into seventy-five separate grades of iron and steel scrap. This paper generally classifies these grades into four major groups:

1. Cast iron.
2. Prepared scrap.
3. Hydraulic bundles.
4. Unprepared scrap.

Scrap preparation has as its purpose the readying of scrap for charging into steelmaking furnaces or for foundry use. Light scrap can be baled or bundled and all scrap can be cut small enough to give the maximum economy and density in the charging pans. This size varies from mill to mill depending upon box size, door size, handling facilities, etc.

Besides size requirements, scrap quality and alloy possibilities have now entered the scrap preparation picture. Conservation of expensive and scarce alloy materials requires that scrap containing these elements be segregated and used only in heats where the alloy can be utilized. In addition to desirable alloy content, there is also the undesirable or contaminated scrap to be handled. Insofar as preparing scrap physically for size is concerned, it is usually done by either drop ball, torch, shear or press.

One of our major problems at the present time — fully as important as sizing scrap and increasing density — is removing contamination, principally non-ferrous metals.

Because of the deleterious effect upon the finished product and upon the furnace itself, elimination of certain of these materials from the scrap is quite important, particularly where a high scrap charge is used. Non-ferrous materials which cause trouble in the open hearth are lead, zinc and aluminum. These metals affect the operation of the furnace and attack the refractory lining of the furnaces. Copper, aluminum, tin and sulphur cause trouble metallurgically and should also be removed from the scrap charge.

"GROUNDED VS UNGROUNDED LOW-VOLTAGE A-C SYSTEMS"

by H. B. THACKER, Distribution Engineer, Industry Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

H. B. THACKER

▲ EARLY industrial plant distribution systems were almost universally operated without neutral grounding. The advantage of being able to continue operation of a distribution circuit when a ground occurred in some device or portion of the circuit was an important reason for this. Also the common use of 440 or 550 volts supplied from delta-connected transformer banks and the additional cost of wye-connected three-phase transformers with the neutral available for grounding discouraged the use of three-phase four-wire grounded neutral distribution.

There has been a decided trend toward grounding low-voltage systems in industrial plants in the last ten years. Some reasons for this are:

1. More positive location of ground faults by tripping out only the affected circuit.
2. Reduction of the possibility of multiple failures of equipment and circuits from overvoltages due to ground faults.

Both of these reasons have assumed greater importance with the tremendous growth in industrial systems and electric power usage. A third reason tending to increase the use of grounded systems has been the development and usage of higher voltage lighting supplied at 265 volts and making attractive the use of three-phase, four-wire, 460/265Y volt distribution.

The paper discusses the advantages and disadvantages of grounded and ungrounded systems bringing out that, in general, neutral grounding is preferred, but that under certain operating conditions there are many applications where the ungrounded system provides an additional and highly desirable degree of service continuity. Methods of grounding both new and existing systems are discussed.

"CATHODIC PROTECTION OF MILL GROUNDING SYSTEMS"

by J. F. Headlee, Electrical Design Engineer, Construction Engineering Bureau, United States Steel Corp., Fairless Hills, Pa.

J. F. HEADLEE

▲ IN the past 50 years, the electrical power industry has developed into a complex and diversified system. In this period, many advances have been made in the grounding of circuits and equipment. Two sources produce electrolysis in such a system, stray currents from d-c generator sand galvanic currents from two dissimilar materials in an electrolyte.

The paper covers a method of cathodic protection for the galvanic current type of electrolysis. Since the primary purpose of the ground system is to limit the rise of potential on a circuit during fault conditions, it is necessary that a relatively low resistance to earth is necessary to establish the use of suitable ground electrodes. The paper covers the description of the design and installation of the grounding systems at the Fairless Works of the U. S. Steel Corp. as a typical case of cathodic protection. In setting up this system, soil samples were tested which gave readings of 22,500 to 28,000 ohms per cm.

Since this was high, 40-ft, 1½-in. diameter rods were driven deep into the earth where a better conductivity was found. Two of these steel rods are protected by one 10-ft long, 4 × 4-in. square, magnesium anode rods cast on the center of a 20-ft long, 1-in. diameter steel rod. It is believed that the steel ground rods with this cathodic protection will last indefinitely and it is estimated that the magnesium anodes should last about 20 years.

"INTEGRATED ELECTRICAL EQUIPMENT FOR BLAST FURNACES"

by C. P. HAMILTON, Application Engineer, General Electric Co., Schenectady, N. Y.

C. P. HAMILTON

▲ THE modern blast furnace uses such a large number of electrically operated drives, that it seems appropriate to examine the overall requirements in terms of an integrated system. In any continuous process, in which category a blast furnace can be placed, reliability of the system as well as of the essential drives is of paramount importance. Loss of production, and possibly damage to the furnace, as a result of an electrical failure can be costly. In recognition of these important facts, it is the purpose of this paper to start with the power source for a typical installation and follow the distribution through to the various utilization components. Also, the components in the system, that will assure the greatest degree of continuity of service and ease of installation, maintenance and fault correction, are critically examined. Since a number of papers have been presented on skip hoist drives and program control, these proportions of the system are only covered to the extent of those points that are pertinent to the purpose of the paper and to include as well some new novel schemes of operation that have been developed.

"WATER SUPPLY FOR STEEL PLANTS"

by ROSS NEBOLSINE, President, Hydrotechnic Corp., New York, N. Y.

▲ THE paper is mainly concerned with water requirements of integrated steel plants. A brief review of the water supply requirements of the steel industry is given in comparison with other users. This is followed by a discussion of the water needs of integrated steel plants. Several tables are included. Examples of water conservation by steel plants in California, Utah, Maryland, and Ohio are given to show utilization of supply.

ROSS NEBOLSINE

The paper describes the various water quality requirements of steel plants. It gives discussion of sources of supply usually consisting of river and lake intakes and also wells. Typical intakes and pumping stations are described, including methods of protecting the steelmaking facilities should a power failure, or other accident, temporarily shut down part of the water supply system.

Several water intakes and pumping stations are described and illustrated as follows: (1) a river pumping station on a very shallow river for the Chile Steel mill; (2)a large capacity Great Lakes intake having a separate pumping station adjacent to the main power station; (3) a caisson type intake and pumping station using vertical pumps to solve the problem of a river such as the Ohio having a very high flood stage, and (4) the river pumping station of the new Fairless Works at Morrisville, Pa., which incorporates special facilities for flexibility of operation.

The paper also discusses distribution system practice including three different network flow diagrams.

"ULTRASONICS IN MAINTENANCE PLANNING AND PRODUCT QUALITY CONTROL"

by R. L. RECTENWALD, President, Maintenance Engineering Corp., Pittsburgh, Pa.

R. L. RECTENWALD

▲ THE subject of this paper covers developments in the field of ultrasonic energy as applied to industrial inspection instruments used for maintenance inspection and new product inspection. The discussion is confined to two basic systems of operation which is fundamental to all of the ultrasonic inspection instruments. A general description is given of the resonance system and of the reflection system and the characteristics and limitations of each is discussed.

As the name implies, the resonance system is one in which the instrument generates an impulse in a quartz crystal or transducer which is transmitted into the material being tested at such a frequency that a condition of resonance is established. The fundamental frequency is a function of thickness of the material and the thickness is read from a circular slide rule scale on the instrument opposite the frequency where resonance

occurred. The instrument most widely used is very light weight, battery operated and the most portable of all of the ultrasonic inspection instruments. It has a thickness measurement range of 1/16 to 12 in. and is used primarily for wall thickness measurements for maintenance testing of corroded process piping, furnace shells, barge hulls and tanks. For new product inspection, it is used to check metal thickness in deep drawing operations, pipe bends, coiled strip, clad metal bond and similar applications.

The reflection system differs from the resonance system in principle and in application. This instrument is a-c operated and weighs almost ten times as much as the resonance unit, but it has a thickness range of about one in. to 20 ft. The function of this instrument is primarily flaw detection although it is used for thickness measurements in heavy sections. The principle of operation is based on the measurement of time interval required for an ultrasonic impulse to travel from the transducer through the material and back from the opposite reflecting surface. The time interval between the instant the signal is released from the transducer and the instant it is received at the same surface is indicated on a scanning line or scale which is projected on a cathode-ray screen. The time measurement is actually read as distance from the measuring surface on the scanning scale. The testing frequency is selected to suit conditions and the signals are emitted in short pulses at 60 times per second.

This instrument is used for detecting flaws in crankshafts, forging hammer rams, piston rods and in new inspection for spotting defects in large forgings, castings, die blocks and billets prior to machining. Special crystals are available for inspection of pipe welds and weldments and a new development in searching unit design will detect surface fractures, laps and seams.

The two systems are complementary because of their overlapping thickness ranges and characteristics which enable them to cover a wide range of thin wall measurements of corroded materials, deep penetration for flaw detection and surface inspections. The incorporation of these inspection instruments in a maintenance planning program would permit better scheduling of major replacements and repairs. It would provide the opportunity to order replacements in advance of scheduled outages, and reduce the possibility of forced outages and accidents which frequently result in extensive damage, loss of production and personnel casualties. Use of the ultrasonic instruments on a routine inspection program also permits safer operation under controlled conditions when it is necessary to operate equipment where known minor defects or corrosive conditions exist.

Where a plant cannot justify the purchase of these instruments and the personnel to operate them efficiently, there are inspection services available on a daily or weekly rate. If the need of this inspection service does not occur weekly or at least monthly, the consulting service of a commercial inspection organization would be more economical and more satisfactory. The wide experience of such organizations with field testing and the availability of an operator who is using the instruments on difficult jobs almost daily enables the commercial testing organization to spot critical points promptly, and to cover more inspections in a given time than the plant inspection engineer who may use the instruments only a few times a year.

"IMPROVED CLEANING TECHNIQUES FOR OPEN HEARTH CHECKERS"

by J. J. ENOCHS, Sales Engineer, Dowell, Inc., Wilmington, Del. and REECE KINCAID, Sales Engineer, Dowell, Inc., Chicago Heights, Ill.

J. J. ENOCHS

▲ DURING open-hearth operations, checker surfaces become coated with slag particles, carbon, and other solids carried in the gases. These deposits cause reduced efficiency by decreasing the rate of heat transfer. Standard practice has been to clean checker chambers mechanically, a process requiring from four to nine days of down time.

A new method employs a chemical solvent directed into the checker chamber at 2500 psi through special jet nozzles. The solution disintegrates the deposit which is then forced into the tunnel by the downrushing air. Chemical cleaning is performed *during operation of the furnace.* No down time is required. The treatment is completed in two and one-half to eleven hours, depending on furnace size. Only a slight, temporary cooling of checkers results. Experience has indicated no measurable amount of spalling.

REECE KINCAID

The value of the chemical cleaning method may be assessed from the increase in tonnage, savings in refractory, and elimination of down time. One steel plant reports a savings of 48 hours down time and $15,000 worth of refractory per furnace. The tonnage output was raised from 22 tons per hour to 24 tons per hour.

"CLEANING OF OPEN HEARTH CHECKERS AND SEWERS DURING OPERATION"

by ROBERT M. JORDAN, Assistant Superintendent No. 3 Open Hearth, Bethlehem Steel Co., Lackawanna, N. Y.

R. M. JORDAN

▲ IT is an established fact throughout the steel industry today that the higher the preheat of the combustion air entering the furnace, the more efficient the operation of the open hearth furnaces will be. During the past several years, much discussion has been given on the subject of increasing the temperature of the combustion air by better checker design, and by keeping the amount of air infiltrated into the checker chambers to a minimum.

The maximum preheat that can be obtained from any one checker design is dependent on the fact that all the flues in the system be in use. If part of these flues become plugged during the campaign of the furnace, with flue dirt, the efficiency of the checker is lowered due to the decrease in the total heating area, and the increase in the flue velocity. This causes the combustion air to have lower preheat, and the corresponding drop in the efficiency of the furnace. Therefore, if a furnace is to be kept operating at top efficiency throughout its campaign life, the checker flues must be kept clean of dirt. Along with keeping the checker flues clean, the sewers must also be kept clean so that the furnace will draft properly, and there will be room for the dirt to go when the checkers are being cleaned.

The methods used to keep various types of checkers clean on furnaces firing Bunker C oil, or Bunker C oil and pitch in combination, and the results obtained by these methods, are discussed in this paper.

"REPUBLIC'S NEW OPEN HEARTH FURNACES AT CLEVELAND"

by E. C. McDONALD, Superintendent, Combustion Dept., Republic Steel Corp., Cleveland, Ohio

E. C. McDONALD

▲ REPUBLIC Steel Corp. has recently completed the expansion of its Cleveland steel plant to include additional capacity in all departments from coke ovens to finished sheet and strip. One of the major features of the program was the erection of another open hearth shop consisting of four 275-net ton furnaces. These furnaces were built with ample dimensions for increasing the capacity to 300 net tons at a later date, and were equipped with the latest features in use in open hearth practice today. The paper describes the entire shop and gives all the important dimensions, and refractory changes made since the beginning of operations. The furnace auxiliaries are also described — the more important of which are instrumentation and control, waste heat boilers, materials handling, fans, reversing valves and flues, and the drained floor system under regenerators and flues. Operating results obtained have been gratifying and are briefly described at the conclusion of the paper.

"NEW OPEN HEARTH FURNACES AT STELCO"

by E. T. W. BAILEY, Chief Combustion Engineer, The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

▲ IN 1950, it became apparent that if Canada were to maintain her present rate of growth, she would need increasingly large amounts of implements, tools and machines, all of which require increasingly large amounts of steel. Stimulated by national alertness and the opportunities which are the heritage of that vigorous young country, this growth and development was proceeding at an accelerated pace. To meet this need, The Steel Co. of Canada, Limited embarked on a large plant expansion program. Recently completed, the new facilities included docks, coke ovens, blast furnace and the new open hearth shop, which will be described in this paper.

E. T. W. BAILEY

The description covers shop design, layout and service equipment. Principal features, dimensions and capacities of major units are included. Emphasis is placed on items that are thought to be different or uncommon to most other shops.

Supplementing the general description, a summary of some of the operating experiences during the first half year will be given. These will include comments on automatic controls, combination gas, and oil-firing and production performance.

"TEMPERATURE DISTRIBUTION IN THE HEARTHS OF BLAST FURNACES"

by Professor V. PASCHKIS, Technical Director, and TAGHI MIRSEPASSI, Research Engineer, Heat and Mass Flow Analyzer Laboratory, Columbia University, New York, N. Y.

PROF. V. PASCHKIS

▲ BLAST furnace break-outs often occur at levels just below the original contour of the hearth. Such break-outs may be attributed to the lack of freezing of the iron as it penetrates between joints of the lining.

A study by computational methods was undertaken to determine the freezing lines of iron in hearths of three different designs.

The depth of penetration of iron is governed to a considerable extent by the conductivity of the mass filling the region between the original contour and the freezing line. The space so defined is called "salamander space." Assuming different values of conductivity of the mass filling the salamander space, the temperature distribution in the bottom of the furnace was determined. Based on the most probable assumption that the salamander space is filled with iron, carbon linings, especially side walls, appear superior to ceramic linings.

TAGHI MIRSEPASSI

It appears that the best lining construction depends on the diameter of the furnace and all work carried out to date is limited to a furnace with a 28-ft diameter.

Recommendations for further work are included in the paper.

"TRENDS IN BLAST FURNACE LININGS"

by HOBART M. KRANER, Ceramic Engineer, Bethlehem Steel Co., Bethlehem, Pa.

H. M. KRANER

▲ THIS paper reviews briefly some recent events in refractories developments which have been responsible for present designs. The raw materials and methods of manufacture of refractories have in large measure dictated the reasons by which we attained our present designs. Furnace practices developed over the years also placed certain limitations upon these developments. The influence of war, requiring continuous furnace operation, the high cost of scrap, and the rapidly rising relining costs stimulated developments which would prolong lining life and cut down repair delays.

In the case of carbon most of our people approached the use of this material timidly, using it as a hot face lining, which was a mistake. Now we have come to realize that the high thermal conductivity of carbon is an asset of which advantage should be taken. We now put carbon against the shell of the furnace where it is exposed to cooling. Metal solidifies in the joints. Physical properties of several types of carbon are now known and carbon bricks are being tried. Results look attractive.

Manufacturers of clay brick are cooperating very well in producing brick which will resist disintegration by carbon monoxide, and these efforts have been effective. These brick have improved the conditions, particularly in respect to the throat and the shape of the hearth bottom wear lines and, along with the carbon developments, have resulted in a hearth design which is different from that of the conventional type in general use today. Further improvements will come from interpretation of data from temperature distribution in hearths now under way.

"OILLESS BEARINGS — THEIR PLACE IN INDUSTRY"

by CHARLES D. SPADONE, Vice President, Spadone-Alfa Corp., New York, N. Y.

C. D. SPADONE

▲ THIS presentation provides a working study of oilless bearings and their operation. Stressing practical application, it is intended as a helpful guide for those charged with the responsibility of bearing design or maintenance.

The main types and various structures of oilless bearings are described and distinction is made between "oilless" and "self-lubricating." General characteristics, applications and methods of manufacture are considered with some emphasis placed on types utilizing dry metallic plug lubricants.

Theory of solid lubrication and its effect on solid friction is reviewed in terms of structure and advantages of various mineral lubricants operating on this principle.

A brief history of the first oilless bearing to be developed with a metallic plug lubricant, points out some of the problems inherent in this method of lubrication and provides background for an analysis of bearing properties pertaining to this member of the oilless group.

Recent developments and experimentation with new ingredients as aids to dry lubrication are discussed and conditions of load, speed, temperature and running clearance offered as guides to the proper selection of bearings for given applications.

Flexibility in design of metallic plug bearings, sizes, shapes, uses and methods of manufacture are fully covered and practical suggestions offered regarding choice and application.

General engineering data includes optimum bearing dimensions, performance of bearings under actual operating conditions, load speed, temperature and frictional limitations. It is pointed out that other variables enter in to the success or failure of bearing operation and that due consideration should be given to these contributing factors when making final bearing selection.

"LAMINATED FABRIC BEARING MATERIALS"

by RICHARD L. BERRY, Manager, A-B-K Sales, American Brakeblok Division, American Brake Shoe Co., Detroit, Mich.

R. L. BERRY

▲ THIS paper deals with the origin of the laminated fabric bearing with the methods by which these are currently manufactured, and explanation of the different bearing formulations currently available in the field. Some conclusions are drawn from field experience in the performance of bearings, and different type applications and suggestions are offered as to the method of lubrication, type of lubricant to be used and the speeds, temperatures and pressures that laminated fabric bearings will sustain in the various type applications which they currently enjoy in the rolling mills industry.

The evolution of the enclosed neck design is traced, indicating the various steps that were made in the design to the present day enclosed neck assembly incorporating laminated plastics.

Suggestions are offered as to modifications in bearing designs for extraordinary applications for supplementary lubrication where other than water is required.

"APPLICATION OF BRONZE BEARING ALLOYS"

by JAMES L. DUCHENE, Sales Representative, National Bearing Division, American Brake Shoe Co., Pittsburgh, Pa.

J. L. DUCHENE

▲ THE proper application of any bronze as a bearing material may be likened unto a triangle, with the three sides being design, material, and maintenance.

This paper touches on design and maintenance, but concentrates on the material side of the triangle. Selection of the proper bearing alloy is in a sense a compromise but the desirable and undesirable factors as well as the physical properties of various bearing alloys are discussed.

New methods of manufacture of bronze sleeve bearings are explained to show an increase in service life as well as a decrease in bearing costs. A conclusion is reached with the aid of several case histories to show that bronze bearing life can be increased. Several general suggestions are then offered as to how this goal can be attained.

"ACTIVATED ALUMINA FOR THE MAINTENANCE OF GAS ENGINE CRANKCASE OILS"

by LOWRIE B. SARGENT, JR., Assistant Chief, and E. M. KIPP, Chief, Lubricants Division, Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa.

L. B. SARGENT, JR.

▲ THE operation of an aluminum reduction plant during the recent war involved a pioneering engineering project in that vast quantities of electric power were generated by means of a large number of gas-burning internal combustion engines. The necessity for continuous operation, greatly emphasized the maintenance of all equipment, particularly the engines. The power house had a potential of about 123,000 hp and consisted of 68 engines ranging from 1165 to 3600 hp each. In this situation, the maintenance of the crankcase lubricating oil was an important economic and operational factor.

E. M. KIPP

This paper summarizes the results obtained from full-scale field experiments designed to determine the relative effectiveness of various bulk filtering media in maintaining the quality of crankcase lubricating oils. Activated aluminas are shown to be superior to other bulk media for the continuous maintenance, on a by-pass basis, of crankcase lubricating oil of the non-inhibited type used in this operation. In addition, the interfacial tension evaluation appears to be the best single method of determining the condition of the crankcase lubricating oils with respect to oxidation deterioration.

Throughout the test program, the interior crankcase surfaces of the engines whose oils were being maintained with activated alumina were exceptionally clean. No evidence of bearing troubles associated with the use of the filters was observed. The testing program extended for approximately one year, with the best performance being shown by an activated alumina filter.

"IMPORTED ORE HANDLING — MACHINES AND PRACTICES"

by ERLE M. HAYS, Sales Engineer, Crane & Bridge Dept., Engineering Works Division, Dravo Corp., Pittsburgh, Pa.

E. M. HAYS

▲ AS the American steel industry reaches out across oceans to supplement this country's reserves of iron ore, the need for fast and economical methods of transferring this heavy raw material from ships to rail cars, stock pile or barges is readily apparent.

The problems to be considered in unloading and handling imported ore may be classified in three general groups:

1. Types of ships,
2. Types of unloading machines and clean-up equipment for ships' holds, and
3. Methods of ore transfer from ships' rail to railroad cars, stock pile or barges.

Only a few ships specifically designed for transportation of foreign ore, comparable to those used on the Great Lakes, are in current ocean use. As ore traffic increases, there undoubtedly will be built an increased number of specially designed ocean ore carriers, some having up to 40,000-ton capacity.

A large percentage of imported ore is being carried today in the standard ocean freighters of the American designed C2, C3, Liberty and Victory types. These types of ships, with small hatches and one, two, or three decks, complicate the problem of unloading, in particular the ore stowed on and under the 'tween-decks, in the forward hold and in the after holds around the propeller shaft tunnel.

The design of modern ore unloaders must take into consideration the fact that for many years in the future, standard freighters will be transporting ore along with carriers specifically designed for the trade. The man trolley type unloader was selected and designed for this service.

For unloading the freighter type ships, means are provided for the bucket's direction of opening and closing to be operated at right angles to or parallel with the direction of travel of the unloader man trolley. This permits the bucket to reach some distance beyond the hatch opening under the deck and remove ore.

All the ore beyond the hatch opening under the deck

on ocean freighters cannot be reached by the unloader bucket, and it is necessary to use such equipment as bulldozers, loaders, slushers, and ship's rigging bucketing to pull out this ore.

The basic problems in ore pier handling and transfer operations are related to loading railroad cars or barges to their maximum capacity in a minimum amount of time without delaying at any time the ships unloading operation and without excessive rehandling. Use of conveyor systems and automatic weighing and loading equipment has done much to overcome these problems.

"APPLICATION OF SELF-CENTERING ROLLS FOR STRIP PROCESSING LINES"

by E. T. LORIG, Chief Development Engineer, United States Steel Corp., Pittsburgh, Pa.

E. T. LORIG

▲ APPLICATION and uses of automatic self-centering rolls in metal strip processing lines have progressively become greater over the past three years. Such rolls are designed and constructed in accordance with the principles expounded in a paper titled "Automatic Self-Centering Rolls and Pulleys" presented at the 1950 Annual Convention AISE in Cleveland, Ohio on September 26, 1950.

While reports on strip centering rolls applied during this period can in general be considered effectively good, yet it becomes evident from a few reports received that insufficient knowledge exists throughout the industry of the centering principles involved and of their proper application to uniformly secure the effective strip tracking results which automatic self-centering rolls have to offer.

The writer wishes to comment at this point that the above-mentioned lack of knowledge is entirely excusable. The subject of automatically centering moving strip over rolls mechanically, without benefit of detrimental edge guides, is still in its infancy. Little published matter is available to those interested to provide a guide toward securing the required knowledge in design placement of rolls in processing systems.

Much has been learned in the past three years about the matter of practically centering and aligning moving strip in process. The installation of automatic self-centering rolls, together with subsequent developments in the shaping of associated plain rolls, have contributed greatly to the proper functioning of such lines at any speed under desirable strip tensions.

Further experimental work has been carried on to a considerable extent since presentation of the paper in 1950. This work did not deviate from the principles expounded at that time, but was of a nature involving the use of working models to assist in solving tracking in existing troublesome processing systems. The indications were that for complicated systems the self-centering rolls developed could not be positioned indiscriminately to secure effective centering — that adverse factors causing the troubles were strongly opposed to correction without strategically locating the centering rolls.

The paper is supplementary to that on automatic centering rolls and pulleys published in 1950. It deals with some phases of the practical applications, including a description of the several types of rolls recently developed, reasons why such developments were necessary, how they function, etc. Information is also presented on the effect that variable longitudinal and cross-sectional contour of strip has on trackability and how the resultant erratic behavior can be improved.

"SYSTEM ENGINEERING FOR CONTINUOUS STRIP PROCESSING LINE"

by J. S. APPERSON, Steel Mill Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

J. S. APPERSON

▲ STRIP processing lines have come of age and require the same system engineering approach in their design and layout as do tandem cold strip mills, continuous hot strip mills and large reversing blooming and slabbing mills. The trend in the steel industry to combine more and more strip processing operations into continuous processes requires that highly specialized engineering skills be applied to the problems of coordinating the various phases of these lines into one smooth working facility. New products and equipment have been developed to solve the special problems created by the continuous production philosophy, and careful attention to all components of the installation are necessary to insure uninterrupted production.

The electrical application engineer must find the best way consistent with economic considerations to achieve the desired overall operating results, and must consider the elements of production requirements, quality of the material produced, labor costs, cost of maintenance and the availability of the equipment.

This paper mentions several recent and outstanding installations and describes the complexity of the electrical equipment in order to show the importance of system engineering. Detailed reference is made to a recent continuous electrolytic tinning line installation.

The numerous feedback regulating systems employed on this line are described to show how each must perform its basic function as well as coordinate successfully with other elements of the equipment.

Several of the many special tools developed by the electrical industry to meet demands of continuous strip processing are described.

Each new continuous strip processing line involves the combination of a number of existing elements and combined perhaps in a manner differing from previous experience. Also, the problems involved may necessitate the development of some new tool. The electrical industry stands prepared to analyze each new proposal to find the best combination of existing tools and to

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J. L. DUCHENE

▲ THE proper application of any bronze as a bearing material may be likened unto a triangle, with the three sides being design, material, and maintenance.

This paper touches on design and maintenance, but concentrates on the material side of the triangle. Selection of the proper bearing alloy is in a sense a compromise but the desirable and undesirable factors as well as the physical properties of various bearing alloys are discussed.

New methods of manufacture of bronze sleeve bearings are explained to show an increase in service life as well as a decrease in bearing costs. A conclusion is reached with the aid of several case histories to show that bronze bearing life can be increased. Several general suggestions are then offered as to how this goal can be attained.

"ACTIVATED ALUMINA FOR THE MAINTENANCE OF GAS ENGINE CRANKCASE OILS"

by LOWRIE B. SARGENT, JR., Assistant Chief, and E. M. KIPP, Chief, Lubricants Division, Aluminum Research Laboratories, Aluminum Co. of America, New Kensington, Pa.

L. B. SARGENT, JR.

▲ THE operation of an aluminum reduction plant during the recent war involved a pioneering engineering project in that vast quantities of electric power were generated by means of a large number of gas-burning internal combustion engines. The necessity for continuous operation, greatly emphasized the maintenance of all equipment, particularly the engines. The power house had a potential of about 123,000 hp and consisted of 68 engines ranging from 1165 to 3600 hp each. In this situation, the maintenance of the crankcase lubricating oil was an important economic and operational factor.

E. M. KIPP

This paper summarizes the results obtained from full-scale field experiments designed to determine the relative effectiveness of various bulk filtering media in maintaining the quality of crankcase lubricating oils. Activated aluminas are shown to be superior to other bulk media for the continuous maintenance, on a by-pass basis, of crankcase lubricating oil of the non-inhibited type used in this operation. In addition, the interfacial tension evaluation appears to be the best single method of determining the condition of the crankcase lubricating oils with respect to oxidation deterioration.

Throughout the test program, the interior crankcase surfaces of the engines whose oils were being maintained with activated alumina were exceptionally clean. No evidence of bearing troubles associated with the use of the filters was observed. The testing program extended for approximately one year, with the best performance being shown by an activated alumina filter.

"IMPORTED ORE HANDLING — MACHINES AND PRACTICES"

by ERLE M. HAYS, Sales Engineer, Crane & Bridge Dept., Engineering Works Division, Dravo Corp., Pittsburgh, Pa.

E. M. HAYS

▲ AS the American steel industry reaches out across oceans to supplement this country's reserves of iron ore, the need for fast and economical methods of transferring this heavy raw material from ships to rail cars, stock pile or barges is readily apparent.

The problems to be considered in unloading and handling imported ore may be classified in three general groups:

1. Types of ships,
2. Types of unloading machines and clean-up equipment for ships' holds, and
3. Methods of ore transfer from ships' rail to railroad cars, stock pile or barges.

Only a few ships specifically designed for transportation of foreign ore, comparable to those used on the Great Lakes, are in current ocean use. As ore traffic increases, there undoubtedly will be built an increased number of specially designed ocean ore carriers, some having up to 40,000-ton capacity.

A large percentage of imported ore is being carried today in the standard ocean freighters of the American designed C2, C3, Liberty and Victory types. These types of ships, with small hatches and one, two, or three decks, complicate the problem of unloading, in particular the ore stowed on and under the 'tween-decks, in the forward hold and in the after holds around the propeller shaft tunnel.

The design of modern ore unloaders must take into consideration the fact that for many years in the future, standard freighters will be transporting ore along with carriers specifically designed for the trade. The man trolley type unloader was selected and designed for this service.

For unloading the freighter type ships, means are provided for the bucket's direction of opening and closing to be operated at right angles to or parallel with the direction of travel of the unloader man trolley. This permits the bucket to reach some distance beyond the hatch opening under the deck and remove ore.

All the ore beyond the hatch opening under the deck

on ocean freighters cannot be reached by the unloader bucket, and it is necessary to use such equipment as bulldozers, loaders, slushers, and ship's rigging bucketing to pull out this ore.

The basic problems in ore pier handling and transfer operations are related to loading railroad cars or barges to their maximum capacity in a minimum amount of time without delaying at any time the ships unloading operation and without excessive rehandling. Use of conveyor systems and automatic weighing and loading equipment has done much to overcome these problems.

"APPLICATION OF SELF-CENTERING ROLLS FOR STRIP PROCESSING LINES"

by E. T. LORIG, Chief Development Engineer, United States Steel Corp., Pittsburgh, Pa.

E. T. LORIG

▲ APPLICATION and uses of automatic self-centering rolls in metal strip processing lines have progressively become greater over the past three years. Such rolls are designed and constructed in accordance with the principles expounded in a paper titled "Automatic Self-Centering Rolls and Pulleys" presented at the 1950 Annual Convention AISE in Cleveland, Ohio on September 26, 1950.

While reports on strip centering rolls applied during this period can in general be considered effectively good, yet it becomes evident from a few reports received that insufficient knowledge exists throughout the industry of the centering principles involved and of their proper application to uniformly secure the effective strip tracking results which automatic self-centering rolls have to offer.

The writer wishes to comment at this point that the above-mentioned lack of knowledge is entirely excusable. The subject of automatically centering moving strip over rolls mechanically, without benefit of detrimental edge guides, is still in its infancy. Little published matter is available to those interested to provide a guide toward securing the required knowledge in design placement of rolls in processing systems.

Much has been learned in the past three years about the matter of practically centering and aligning moving strip in process. The installation of automatic self-centering rolls, together with subsequent developments in the shaping of associated plain rolls, have contributed greatly to the proper functioning of such lines at any speed under desirable strip tensions.

Further experimental work has been carried on to a considerable extent since presentation of the paper in 1950. This work did not deviate from the principles expounded at that time, but was of a nature involving the use of working models to assist in solving tracking in existing troublesome processing systems. The indications were that for complicated systems the self-centering rolls developed could not be positioned indiscriminately to secure effective centering — that adverse factors causing the troubles were strongly opposed to correction without strategically locating the centering rolls.

The paper is supplementary to that on automatic centering rolls and pulleys published in 1950. It deals with some phases of the practical applications, including a description of the several types of rolls recently developed, reasons why such developments were necessary, how they function, etc. Information is also presented on the effect that variable longitudinal and cross-sectional contour of strip has on trackability and how the resultant erratic behavior can be improved.

"SYSTEM ENGINEERING FOR CONTINUOUS STRIP PROCESSING LINE"

by J. S. APPERSON, Steel Mill Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

J. S. APPERSON

▲ STRIP processing lines have come of age and require the same system engineering approach in their design and layout as do tandem cold strip mills, continuous hot strip mills and large reversing blooming and slabbing mills. The trend in the steel industry to combine more and more strip processing operations into continuous processes requires that highly specialized engineering skills be applied to the problems of coordinating the various phases of these lines into one smooth working facility. New products and equipment have been developed to solve the special problems created by the continuous production philosophy, and careful attention to all components of the installation are necessary to insure uninterrupted production.

The electrical application engineer must find the best way consistent with economic considerations to achieve the desired overall operating results, and must consider the elements of production requirements, quality of the material produced, labor costs, cost of maintenance and the availability of the equipment.

This paper mentions several recent and outstanding installations and describes the complexity of the electrical equipment in order to show the importance of system engineering. Detailed reference is made to a recent continuous electrolytic tinning line installation.

The numerous feedback regulating systems employed on this line are described to show how each must perform its basic function as well as coordinate successfully with other elements of the equipment.

Several of the many special tools developed by the electrical industry to meet demands of continuous strip processing are described.

Each new continuous strip processing line involves the combination of a number of existing elements and combined perhaps in a manner differing from previous experience. Also, the problems involved may necessitate the development of some new tool. The electrical industry stands prepared to analyze each new proposal to find the best combination of existing tools and to

develop new tools where necessary. By using the available highly specialized engineering skills and the system engineering approach further steps can certainly be made toward the ultimate goal of making the entire production of cold strip a continuous automatic operation.

"INTRAPLANT HANDLING OF ROUND BILLETS AND PIPE WITH SPECIAL AUTOMOTIVE EQUIPMENT"

by J. D. TYSON, Superintendent, Warehousing and Shipping Dept., National Tube Division, United States Steel Corp., Lorain, Ohio

J. D. TYSON

▲ THE National Tube division recently completed a large construction program at its Lorain plant involving the expansion of steelmaking, rolling, finishing and warehousing facilities. With this increase in rolling and finishing mill capacity, many problems arose in regard to handling semi-finished billets and finished tubular products within the mill. This paper describes how many of these problems were resolved by the utilization of heavy capacity fork and straddle truck equipment. A new concept of stocking material in open areas is described by which a "horizontal" principle of storage is used, as compared to the previous method of "vertical" piling under crane runways. Examples are given to illustrate how this type of transportation between producing and consuming mills provides a flexible means of altering material handling procedures to conform with expanding plant operations. The new procedures in stocking and transportation have expedited the flow of material throughout the plant and removed restrictions on the operating units which resulted in many mill delays. Although it was originally believed that inclement winter weather and the temperature of the material being handled would be major deterrents to this type of transportation, they have not seriously affected equipment performance.

Dispatching the movement of automotive equipment involved in the handling of rounds and pipe is accomplished by two-way radio communication which has resulted in increased utilization and efficiency of the equipment.

It is emphasized that proper maintenance of fork and straddle trucks, bolsters, roadways, and field storage areas is essential for good equipment performance.

"TEMPER MILL CONTROL"

by GEORGE P. DIRTH, Electrical Engineer, Granite City Steel Co., Granite City, Ill.

▲ CONTROL circuits of a modern two stand temper mill are complex. Rolling strip under tension requires that five different values of constant tension be maintained during rolling. Tension must be held between the delivery side of stand No. 2 and delivery tension device to pull out all ripples in the strip. Different values of tension are held between stands No. 1 and 2, entry and delivery reels and tension devices.

G. P. DIRTH

The strip is worked to an elongation of from 2 to 4 per cent between stands No. 1 and 2. At this point, the forward pull equals the backward pull.

All five tensions are controlled and regulated electrically by employing some form of a regenerative system. Behind the balance point between stands No. 1 and 2, the various d-c machines act as generators; ahead of this point as motors. Either a common bus with boosters or a combination of separate bus and common bus can be used. One practical system in use is to have a separate bus for the entry and delivery reels, a common bus for both the entry and delivery tension devices and work stands. The regulating methods used are:

1. By regulating motor fields for current or tension.
2. Voltage control of separate generators for current or tension.
3. Regulating boosters on common bus to control applied armature voltage for current or tension.

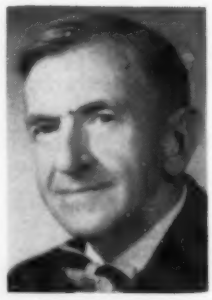
In addition, temper mill control systems usually include:

1. Variable voltage control.
2. Variable field (torque) control.
3. WR^2 compensation.
4. IR drop compensation.
5. Load balance between pairs of work drives and tension roll drives.

The temper mill, as a high speed mill, with all of its complex controls is now one of the most complicated of all modern steel mill machines.

"ESTIMATING MOTOR ROOM INSTALLATION COSTS"

by WRAY DUDLEY, Chief Consulting Engineer, Patterson-Emerson-Comstock, Inc., Pittsburgh, Pa.



WRAY DUDLEY

▲ THE cost of motor room installations represents a substantial expense item in the overall investment for any sizeable steel mill project. If a simple, reliable formula for advance estimating of these costs could be developed which would be applicable to the different types of motor room installations encountered, it would be of considerable value for use when preliminary plans for a proposed new project are under consideration.

Examination of published literature on this subject fails to disclose any generally accepted formula, although it is recognized that methods of some type must be in general use. These methods may apply some ratio calibrated against power requirements of the mill, electrical equipment costs, production capacity or some other predetermined value. Information on this phase of this subject is inconclusive and additional data from interested numbers would be of value.

Examination of installation costs for 36 steel mill motor room installations discloses a wide range in unit cost values. From these records an average unit cost per hp installed is developed and boundary unit cost limits for these installations are quoted. Specific examples are given of job conditions which cause wide variations in costs and numerous physical features are described which exert a similar influence.

Other features of a less tangible nature which exist on every installation in greater or less degree and which exert a variable influence at different installations, are also discussed. Included in this category are such items as supervision, co-ordination among work groups, labor rates, weather conditions and urgency of completing the job and other intangibles.

The writer concludes there is at present no simple, easy method of estimating motor room installation costs where a close degree of accuracy is required. However, if budgetary estimates only are involved for mills lacking sufficient skilled estimators to prepare such data, an inexpensive procedure for obtaining estimates of this character is suggested.

"CRANE POWER LIMIT SWITCHES"

by ROBERT W. GRAHAM, Superintendent Electrical Dept., Bethlehem Steel Co., Lackawanna, N. Y.

R. W. GRAHAM

▲ IN 1949, an attempt was made by AISE Standardization Committee to see if anything could be done to standardize power crane limit switches. A questionnaire was sent to various steel plant operating departments, crane builders, and manufacturing companies as to what they would most prefer if it were possible to standardize on this equipment.

Inasmuch as there are only two manufacturers of this type of equipment, each of whom had made recent rather radical changes in their equipment, and the market for this apparatus is rather limited, it can readily be seen the reluctance of these manufacturers to alter dimensions to make an interchangeable piece of equipment with its attended cost of design and dies to make this possible. However, it was said if another control builder did enter the field, the information gleaned from this survey could be applied to place a better crane power limit switch on the market.

As the Standardization Committee saw it, the results of the survey should be passed out to the steel operating people for what benefit they would get out of it.

We believe the result of the survey, at least, brought to the attention of the operating people some of the troubles experienced in the various plants and the suggestions which could be applied to their particular application. If we have done this and saved a few lives by calling attention to the application of proper limit switches and the importance of proper maintenance of crane power limit switches, we feel we have accomplished something worthy of time spent on it.

The inquiry covered such items as:

1. Number of cranes equipped with power limit switches.
2. Failures per year on limit switches.
3. Causes of limit switch failures.
4. If new limit was available, what are some of the points you would improve on?
5. Can we improve on circuits presently available?
6. Difficulties experienced in present wiring schemes due to operators mishandling controls.
7. Proper mounting location of limit switches.
8. Proper application of tripping appurtenances.

"GROWTH POSSIBILITIES OF ELECTRIC FURNACE CARBON STEEL"

by W. C. WHEELER, Management Consultant, New York, N. Y.

W. C. WHEELER

▲ IN presenting this outline of the growth potential of electric furnace carbon steel, the writer wishes to make it perfectly clear that he is not a steel man and makes no pretensions as to technical knowledge of steel processes and practice. Neither is he the champion of any process, practice or interest. He is a specialist in analyzing trends affecting the economics of business management and in projecting these trends so as to alert management, in advance, regarding the probable conditions under which business must operate in the future.

The changes which have taken place in the relative volumes of steel produced by various processes are basically similar to the changes in other industries, the textile industry for example.

The growth in tonnage of electric furnace alloy steel ingots is typical of the growth of such things as rayon and acetate fibers, electric washing machines, automobiles, Phillips screws, etc.

The growth in tonnage of electric furnace carbon steel ingots, over the past ten years, is following closely the path of electric furnace alloy steel ingots traced thirty years earlier and therefore, the path of these other things, too.

The future growth of electric furnace carbon steel ingots will be exceptional only, if it does not continue to follow these typical patterns through the final phase as it has through the earlier phases. If it does conform to justified expectations, then electric furnace carbon steel ingot tonnage should reach a level of 30 per cent of total steel ingots somewhere between 1970 and 1975.

At that time, total steel ingots should be at the level of 157,000,000 tons and carbon steel ingots at the level of 142,000,000 tons. Electric furnace carbon steel ingots would therefore reach a volume of some 43,000,000 tons.

This projected growth *is not predestined.* It is *potentially possible.* It *can occur* if appropriate top management decisions are made by a variety of companies and interests involved.

The writer fully realizes that many technical arguments may be advanced as to the difficulties of reaching such a tonnage of electric furnace carbon steel. However, the history of the steel industry gives abundant evidence of the resourcefulness of the technologists in solving problems of equal or even greater magnitude. If top management will give the green light, the writer would not be among those who would sell the technologists short.

"COST COMPARISONS OF THE OPEN HEARTH AND ELECTRIC FURNACE"

by DAVID D. MOORE, Assistant Supervisor, Engineering Economics Division, Battelle Memorial Institute, Columbus, Ohio

D. D. MOORE

▲ THIS paper is a condensation of a recent comprehensive study of the "Comparative Economics of the Open-Hearth and Electric Furnace for Production of Low-Carbon Steel." This paper was prepared at Battelle Memorial Institute by S. L. Case, D. D. Moore, C. E. Sims, and R. J. Lund for a group of fourteen electric utilities and Bituminous Coal Research, Inc., December 31, 1952.

Cost-comparison estimates were made for representative modern plants of 250,000 tons, 500,000 tons, and 1,000,000 tons of ingots per year employing cold-metal practice, and for the latter two sizes using 50-50 hot-metal/cold-scrap practice.

Estimated capital costs for electric-furnace plants were $6,750,000, $10,500,000, and $15,900,000 or about 60 per cent of the cost of comparable-sized open hearths.

"Cost above" was estimated to be somewhat higher for the electric furnace, varying from 50 cents to $1.03 per ton higher for cold-metal practice, and from $2.00 to $2.21 for hot-metal practice.

On the other hand, cost of metallics was estimated to be somewhat lower for the electric furnace, while yields were estimated to be from 1 to 2 per cent higher.

These factors combined to give a net product cost favoring the electric furnace in cold-melt operations, varying from $3.20 per ton of ingot for the 250,000-ton plant to $2.67 per ton for the 1,000,000-ton plant. In hot-metal practice, the net production costs were from $1.10 to $1.31 higher for the electric furnace.

Little basic change may be expected in price competition between coal and oil during the next several years. At most, by 1975, changes may improve economics of the electric furnace by 50 cents per ton of ingot.

A somewhat higher benefit might be gained through improved electric power-generating efficiencies coupled with lowered coal costs. By 1975, this factor might lower electric-furnace costs by 50 cents to $1 per ton of ingot.

Finally, a brief analysis was made of return on investment for the electric furnace and open hearth under various assumed values or selling prices for steel ingots. In cold-melt practice, the electric furnace should yield higher returns on capital invested.

Using hot-metal practice, the open hearth appears to be the lower-cost process. However, the electric furnace, because of its much lower capital cost, may still permit the greater return on capital investment, particularly in areas where selling prices for ingots would permit substantial profits. In other words, local conditions should be examined carefully before deciding on the type of plant to install.

"THE FUTURE OF LARGE ELECTRIC FURNACES COMPARED TO MODERN OPEN HEARTHS"

by FRANK W. BROOKE, Pittsburgh, Pa.

F. W. BROOKE

▲ THIS paper includes charts which show the yearly production of open hearth steel and electric steel since 1869, as well as one which show the 15 items which affect the relative costs and production of each process. A brief description of each item, with special reference to the cost of scrap preparation, the method of scrap charge, relative cost and availability of fuel, and slag control and existing capital investment is given.

The importance of the effect of capital investment in the modern open hearth field is called the major problem the electric furnace will have to overcome in the future in the so-called carbon steel field.

Paper gives a description of how this problem may be met by:

1. Maintaining the existing equipment in the whole plant all the way from the charge in the furnace right through to the finished product.
2. A suitable design of large electric furnace which could infiltrate into a modern open hearth plant without serious increase in capital expenditure.
3. The economical capacity limit for 3-phase electric furnaces.
4. A novel design of a top-charge, six-electrode electric furnace to fit into the modern open hearth plant.
5. A novel method of improving the electrical bottleneck in high powered electric furnaces.

The reasons why the electric furnace can melt down the cold scrap much more rapidly than the open hearth giving the fundamentals involved is discussed.

New auxiliary processes which can be used by the electric furnaces only and which will materially improve its relative position against the open hearth are described as follows:

1. The preheating of the scrap in separate units and its coordination into any future changeover. (Operating data from a pilot plant may be available at the time the paper is presented.)
2. Induction stirring. This claims to reduce the melt down period and definitely facilitates or removes the problem of "slagging-off" in large electric furnaces.

"THE DIRECT ROLLING OF CARBON STEEL INGOTS TO PLATES" ON THREE HIGH AND FOUR HIGH PLATE MILLS

by ROBERT C. McMICHAEL, Supervisor 112-120-in. Mills, Lukens Steel Co., Coatesville, Pa.

R. C. McMICHAEL

▲ TWENTY years ago when a mill superintendent was asked to roll 3/16-in. gage plate to a width approaching the capacity of his mill, he would usually shudder and immediately begin concentrating on precautions that would have to be taken to make the rolling of the plate possible. The modern four-high mill has not only made the rolling of such plates possible but practical, with a minimum of precautionary measures.

At the outset of World War II, most of the plates over 90 in. wide produced in the United States were being rolled on three-high mills. However, as far back as 1917, Lukens Steel Co. had installed a four-high 206-in. mill. When the demand for plates became so great in the early war years, Lukens installed a modern 120-in. four-high mill (1943) in line with its then producing 112-in., three-high mill. This greatly improved Lukens ability to satisfy the demand for quality plates.

This paper deals with the direct rolling practice at Lukens, how it operates, the difficulties involved, and some of the results that are obtained. Considerable discussion is given to the experiences at Lukens with the direct rolling of ingots to plates on three-high and four-high mills.

At Lukens, the four-high mill has been found to have a number of advantages over the three-high mill.

Some of these advantages are:

1. Use of two working rolls, each supported by a backing roll gives much stronger construction.
2. Four high design permits the use of stationary tables.
3. More modern bearing arrangement on later mills.
4. Higher finishing temperatures.
5. Variable speed permits the proper adjustment of speed with draft to obtain a good quality plate in a minimum time.
6. Higher yield of prime plates.

Some of the disadvantages of the three high mill are:

1. Those imposed by the small middle roll.
2. Those imposed by the tilting tables.
3. Constant speed, non-reversing characteristics of the mill.
4. High "spring" in the mill due to light construction, older bearing design.
5. Limitations on maximum length and width of plates imposed by mill design.

"TEMPERATURE GRADIENTS AND STRESSES IN IRON WORK ROLLS"

by CHARLES F. PECK, JR., Assistant Professor, Juan M. Bonetti, Doctoral Fellow, and Frederic T. Mavis, Head, Dept. of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

C. F. PECK, JR.

▲ THE paper is an interim report based on studies made at Carnegie Institute of Technology for a research project under the sponsorship of the Association of Iron and Steel Engineers and Roll Manufacturers Institute and financed equally by both groups. This project has now been under way for one year, and was recently extended for a second year. The paper covers the first year's work.

A numerical method for calculating temperature stresses in iron work rolls during rolling operations and the result of some such calculations are presented in this paper. The analysis treats numerically the unsteady heat-flow problem in which size of roll, speed of rolling, temperature of strip, temperature of roll, and heat equivalent of working are variable factors. The problem is based on an example of a 27-in. roll, operating at 57 rpm, after rolling strip for 25 seconds at a temperature of 1840 F. This is equivalent to the passage of a 10-ft slab through stand five of the example in Table XVIII of *The Modern Strip Mill*, published by the Association of Iron and Steel Engineers in 1941. The maximum temperature gradient in the prototype roll is 12,000 F/in. Maximum computed stresses in the roll due to this temperature gradient only are about 6000 psi tension radially and 70,000 psi compression tangentially. The maximum shear on tangential and radial planes is about 4000 psi.

JUAN M. BONETTI

In addition, observations have been made on strip mill operation, and on rolls which have failed in service. Studies are also being made on internal stresses and on stresses due to other causes such as mill conditions, rolling pressures, etc. Results of this latter work are expected to be available in another year.

F. T. MAVIS

"PROGRESS IN THE DEVELOPMENT AND APPLICATION OF METALLIC RECUPERATORS FOR THE STEEL INDUSTRY"

by E. A. VIEROW, Superintendent, Fuel and Power Dept., Youngstown Sheet & Tube Co., Youngstown, Ohio

E. A. VIEROW

▲ METALLIC recuperators have been talked about and tried for about one hundred and twenty-five years. However, it is only within the past few years that the American steel industry has shown sustained interest.

The metallic recuperator has many advantages for most industrial furnace applications, starting with space requirements and ending with closely controlled combustion, all of which add up to consistently better furnace performance, as well as fuel economy. The prodding influence in the current interest in metallic recuperators in this country has been the demand for increased production and better quality, rather than fuel economy.

The discouraging experience with metallic recuperators in this country some twenty to twenty-five years ago is attributed to lack of experience in design, inadequate materials of construction, dependency on the human element for furnace operation and recuperator protection, and to general lack of attention. Today, recuperator designs have been proven, suitable metals are available, automatic furnace temperature and combustion controls are now widely used, automatic recuperator safeguards are developed, and long life is insured by a little periodic maintenance.

At present only two metallic recuperators are being commercially marketed in the United States for the recovery of waste heat in furnace operations in the steel industry. Various claims are made for each design.

The Thermal Transfer cast metallic recuperator which is extensively used in Europe was first introduced into this country on a continuous buttweld furnace in 1938. In this application, the waste gases which leave the furnace at about 2800 F are tempered to 1800 F before entering the recuperators. These recuperators have been virtually standard on new continuous buttweld furnaces ever since and have also replaced refractory recuperators on some of the older installations. Today there are in the United States and Canada some 27 steel mill furnaces of different types so equipped.

The Hazen tubular metallic recuperator is of American origin and was first installed in 1943 on a billet heating furnace where waste gases to 1900 F are taken directly to the recuperator. There are now some 97 units installed on various types of steel mill furnaces in the United States. On the latest slab heating furnace applications, these recuperators have been installed on the top of the furnace with claims of resultant increased furnace heating capacity. In soaking pits, this recuperator has been used in series with a refractory recuperator in a number of installations.

"HEAT PROCESSING IN INDUSTRY — FACTS AND FIGURES"

by FREDERIC O. HESS, President, Selas Corp. of America, Philadelphia, Pa.

F. O. HESS

▲ IN this presentation some new test data about industrial heating operations is reported. These data are partly secured in laboratories, but the majority are from actual industrial production installations.

In the presentation and interpretation, special emphasis is upon the effects of heating on the structure as well as the properties of the heated product. In addition reference is made to the effects on design and operation requirements of the heating devices. The various examples are illustrated by slides, photomicrographs and heating curves, and they include heating of large metal masses, such as billets and steel ingots, as well as slabs. Short cycle heat treatment of large steel mill rolls, with illustrations of the heat distribution pattern are discussed, and also a brief report is given on continuous annealing steel strip in a production installation. Short cycle normalizing on a high tonnage production basis is shown, and the metallurgical and operating results are presented.

New developments in the heating equipment for the oil and chemical industry are shown, and the effect upon material requirements, such as steel tubing and high temperature alloys is projected.

The presentation includes an abstract of a long range investigation involving heat transfer in a furnace chamber.

"MODERN ARC FURNACE EQUIPMENT AND PRACTICES"

by E. H. BROWNING, Steel Mill Engineer, Metal Working Section, Westinghouse Electric Corp., East Pittsburgh, Pa.

E. H. BROWNING

▲ THE paper deals primarily with the advancements made in the design and application of electrical equipment used in association with direct arc electric furnaces. These advancements are those covering a period of the last ten to fifteen years. Progress in arc furnace use, design, operation and size over the same period is discussed to show the relation between furnace changes and electrical equipment changes.

Furnace transformers are examined in regard to increase in size, variations of design and arrangement, ranges of primary and secondary voltages available and accessory equipment generally employed.

Switchgear used in arc furnace circuits is treated and such treatment includes description of construction and

operation, operating experience and criteria for the application of oil insulated and air-insulated circuit breakers. Compressed air furnace circuit breakers of the latest design are included in this topic.

Electrode-positioning arc furnace regulators in the forms currently utilized in industry are described and their operating characteristics examined.

Application problems related to the effects of arc furnace operation on power supply systems are outlined and recommended practices in the solution of these problems described.

"NEW SOAKING PIT FACILITIES AT FORD MOTOR CO. STEEL DIVISION"

by B. D. BARNS, Supervisor, and H. E. RAAFLAUB, Senior Fuel & Utilities Engineer, Fuel & Utilities Dept., Steel Div., Ford Motor Co., Dearborn, Mich.

B. D. BARNS

H. E. RAAFLAUB

▲ THE Steel Division of the Ford Motor Co. was faced with a bottleneck in their soaking pits due to increased ingot capacity and arrangement of its stripping facilities. The stripping facilities required a complete rearrangement to handle the increased tonnage. Further expansion of the pit building was impractical and yet it was necessary to increase the tonnage from 1200 tons to 2000 tons. A soaking pit which could be installed with the length of the pit at right angles to the pit building, and allowing its recuperators to be installed under an adjoining control balcony was required. These facilities would permit 2000 tons under cover using approximately 60 per cent of the pit building with 40 per cent available for storage and cover repair space.

"THE DETERMINATION OF OPTIMUM CURRENT IN AN ARC FURNACE"

by W. E. SCHWABE, Research Engineer, National Carbon Research Laboratories, Cleveland, Ohio

W. E. SCHWABE

▲ THE theory concerning the optimum current in an arc furnace is well known and has been described in the literature. The determination of the optimum current at the furnace by experiment in the conventional way is quite involved and is affected by the unsteadiness of current, voltage and power and their meters. A considerably more convenient method is based upon a simple mathematical relation between the phase angle ϕ between current and voltage at short circuit of the arc. The electrodes are immersed in the metal and angle ϕ is determined from meter readings. Optimum current occurs at $\cos\theta = \cos(0.5\phi)$.

The angle $\phi/2$ represents the direction of the vector of the optimum current, the length of which is given by its distance to the intersection with the semicircle in the conventional furnace vector diagram. Exceeding the optimum current results in a higher electrode consumption and lower overall efficiency.

"PROBLEMS IN SUPPLYING POWER TO ELECTRIC FURNACES"

by GEORGE E. DUERR, Industrial Sales Manager, West Penn Power Co., Pittsburgh, Pa.

G. E. DUERR

▲ SOME years ago there were many problems to be faced in supplying power to electric melting furnaces. Thanks, however, to improvements in furnace design, transformer design and controls, and closer cooperation between steel company engineers, manufacturers and utilities, the problem, while not completely eliminated, has been materially alleviated.

Among the problems that deserve early mutual consideration are:

1. Design and capacity of furnaces, electrical requirement, design of furnace transformers and controls.
2. Number of furnaces to be installed and the ability to operate them to achieve best possible load factor.
3. Study of the reactive component of the load and how it can best be supplied.
4. Switchgear specifications that meet both the furnace requirement and the utility's short circuit capacity.
5. Substation design and location.
6. Integration of furnace load with other plant uses.

If full and careful consideration is given to these and any other problems common to the particular locality, lowest possible costs and greatest satisfaction in the use of the furnace equipment will be achieved.

"USE OF PLASTIC, CASTABLE AND GUNNING MATERIALS IN SOAKING PITS"

by W. D. REES, Superintendent, Bar and Blooming Mill, Sharon Steel Corp., Lowellville, Ohio

W. D. REES

▲ SOAKING pit operations, including repairs and maintenance, present many problems, one of which has been fired shape refractories. Consideration of this soaking pit refractory problem at the Lowellville Works, Sharon Steel Corp., resulted in an analysis being made of brick performance under all operating conditions. This analysis of refractory per-

formance convinced us that we must find a material or materials which would outperform brick under normal operating conditions.

Our first experience with these refractory materials was in 1950 when we put a slab-type cover, with a plastic material lining, into service on one of our pits. At the present time, we have slab-type covers in service on all of our pits. Twenty-seven of these covers are lined with a plastic material and two are lined with a castable material.

The satisfactory results we obtained with our plastic lined covers made us willing to try it on a coping when the manufacturer recommended it for this application. The performance this material gave us on our first coping resulted in our deciding to install plastic copings on all pits scheduled for a complete rebuild. At the present time we have plastic copings on sixteen of our twenty-nine pits.

Our favorable experience with plastic material in cover linings and copings led us to extend the application to soaking pit walls. After consultation with the vendor, we installed a plastic material division wall. This installation, from the slag line up, was put into service in January, 1953.

In February, 1953 we installed an outside pit wall using a castable material. The purpose here was to establish a basis of comparison between plastic and castable materials for soaking pit walls. Since this installation we have gradually increased the use of this material in our soaking pits, and at the present time have in service twenty-three walls, eight arches, and four bottoms of castable material.

Repairs and maintenance of fired shape refractories had always been a costly and time consuming operation. After a thorough investigation of a cement gun, through which castable or plastic material in dry form could be shot, we adopted this method of performing repairs and maintenance.

The successful application of these materials in our soaking pits has definitely been a contribution to the following:

1. Increased heating efficiency of our soaking pits.
2. Increased blooming mill production.
3. Economies realized in our soaking pit operations.

"STUDIES ON PROVISION AND USE OF OXYGEN IN STEEL PLANTS"

by GLEN O. CARTER, Partner, Percival R. Moses & Associates, Consulting Engineers, New York, N. Y.

G. O. CARTER

▲ THIS paper covers the growth and the use of oxygen in steel plants from the introduction of air separation processes in 1907 to the present time. Data is given which shows cost of oxygen at points of production and also delivered to steel plants in the chief producing districts. Over $400,000,000 worth of oxygen is now being sold every month of which $1,600,000 worth is being furnished to the steel industry.

The paper also covers details of the steel plant oxygen systems giving data on piping, distribution, metering, and allocation of costs. The paper also discusses reasons for specifying oxygen of specific purities from 95 to 99.5 per cent. The paper also predicts that the cost of oxygen to consumers will go down with greatly expanded use, and it is estimated that such costs may go down as low as $1 per thousand cu ft for demands of 30,000,000 cu ft per month.

"FACTORS AFFECTING THE PERFORMANCE OF HIGH TEMPERATURE GREASES"

by ELDON L. ARMSTRONG, Research Associate, Socony-Vacuum Laboratories, Technical Service Dept., Brooklyn, N.Y.

E. L. ARMSTRONG

▲ GOOD performance of a lubricating grease at high temperatures requires that the product be stable; the overall stability of a grease being determined by many factors such as oxidation stability, resistance of the grease structure to soften or harden excessively, maintenance of a controlled oil bleeding rate, and the evaporation characteristics of the mineral oil or fluid used. In addition, the effectiveness of the grease in reducing wear and surface damage of bearings and other lubricated parts is very important. The essential grease properties must not be destroyed when the product is contaminated with water, dirt, iron oxide and other foreign materials. Often, it is necessary that the grease be compatible with other greases and oils with which it may become mixed in use. Consideration must also be given to rust-prevention and anti-corrosive properties.

Grease products are classified into types depending upon the nature of the thickening agent and/or fluid used. The various factors affecting the performance of the various types are discussed in light of present knowledge of their properties.

With the wider use of laboratory functional type tests to develop, screen and compare new products, it becomes increasingly important that the test results be correctly interpreted. With the complexity of factors determining a grease's overall performance, it is unreliable to use laboratory tests alone as a true measure of a product's merits or limitations. For this purpose, only a field test under actual service conditions can be expected to give the correct rating.

"PUMPABILITY OF STEEL MILL GREASE"

by JOSEPH S. AARONS, Lubricants Chemist, National Tube Div., United States Steel Corp., Pittsburgh, Pa., RICHARD G. WARREN, Lubrication Engineer, United States Steel Corp., Homestead, Pa., and J. J. SEATON, Laboratory Technician, National Tube Div., United States Steel Corp., Pittsburgh, Pa.

▲ THE need for an accurate and relatively short test for determination of grease pumpability is discussed. A review of the "Apparent Viscosity of Greases" test,

listed as an ASTM procedure D-1092-51, and a pumpability test using an air gun of the service station type and requiring 35-40 lb of grease is made. In the case of the ASTM method, the difficulty in interpretation of results as concerns the lubrication engineer and the size of the equipment as related to the air gun pumpability points up the need for a short, convenient, and easily understood method.

The machine parts and procedure are described and some typical results are given. A discussion of field test correlation with laboratory results is given by the co-authors representing the laboratory chemist and plant lubrication engineer.

J. S. AARONS

J. J. SEATON

"STEEL MILL LUBRICATION PROBLEMS"

by A. C. KEISER, JR., Supervising Lubrication Engineer, The Texas Co., Birmingham, Ala.; E. E. PERSO, Supervising Lubrication Engineer, The Texas Co., Los Angeles, Calif.; W. H. MANDY, Engineering Representative, The Texas Co., New York, N. Y.; and M. S. CLARK, Chemist, Technical and Research Div., The Texas Co., New York, N. Y.

▲ LUBRICANTS in steel mills must operate under a greater variety of adverse conditions than in perhaps any other industry. These conditions, as listed below, must be considered when lubricants are selected and applied:

1. Contamination with water, mill scale and dirt.
2. Low as well as high temperature operation.
3. Heavy loads.
4. High speeds.
5. Rough handling.

A. C. KEISER, JR.

A few of the more serious lubricating problems are shown below, along with solutions which have been developed over years of practical experience in the mills.

Water and mill scale contamination of hot and cold strip mill bearing oil systems — It is important that water and mill scale be removed as soon as possible after entering the system.

Solution — 1. Following methods of keeping and getting water out of systems are used:

a. Avoid damage to seals during installation.

b. Use "water legs" to detect roll stand when leakage occurs.

E. E. PERSO

c. Use reclaiming system consisting of two settling tanks (of adequate capacity), heaters, centrifuges and filters.

d. Break tight emulsions by heating oil up to 180-200 F and centrifuging.

e. Use "emulsion breaker" if necessary.

W. H. MANDY

Lubrication of blast furnace tops — Lubrication of bell and distributor mechanism on blast furnace has been a difficult problem because it has been necessary for operators to climb to the top and apply grease with a hand gun.

Solution — Most modern furnaces are equipped with automatic grease systems for lubrication of bell and distributor mechanism and many of the older furnaces are now being equipped with automatic or manually operated systems.

M. S. CLARK

Contamination of lubricating oil in turbo-blower systems — Lubricating oil is subjected to adverse conditions of heat, moisture, dirt and acid atmosphere. Tremendous quantities of air are required for reduction of ore in blast furnaces, and it was often necessary after a few months operation to drain out deteriorated oil and shovel out muck deposits.

Solution — 1. This problem has been largely solved by the following:

a. Use of (R&O) inhibited high grade turbine oils.

b. Cleaning air intake with filters, washers and precipitators.

Preservation of rolls in storage — Mill rolls are often stored for long periods of time and highly polished surfaces soon rust and deteriorate.

Solution — Hard drying preservatives have been used for protection but they are difficult to remove. Petrolatum type applied by spray gun is the most satisfactory since it is self healing when scratched, gives long time protection and is easily removed.

Lubrication of universal spindle couplings — Lubrication of bronze slippers in universal spindle couplings is difficult because centrifugal force has a tendency to throw off the lubricant.

Solution — 1. Problem has never been completely solved but the following methods have been fairly satisfactory:

a. Apply at shut down adhesive extreme pressure lubricants.

b. Drip cylinder oils on spindles during operation.

c. Use chain type oiler.

d. Use enclosed type spindle coupling with "automatic built in" lubrication.

e. Apply spray type lubricant during operation.

A HEAVY DUTY HIGH SPEED ROLL NECK BEARING

By PAUL L. HAAGER
Assistant Chief Engineer
Timken Roller Bearing Co.
Canton, Ohio

. . . . a new bearing, an ingenious hydraulic jack set-up and a new air gage will make it easier to apply bearings to roll necks . . . .

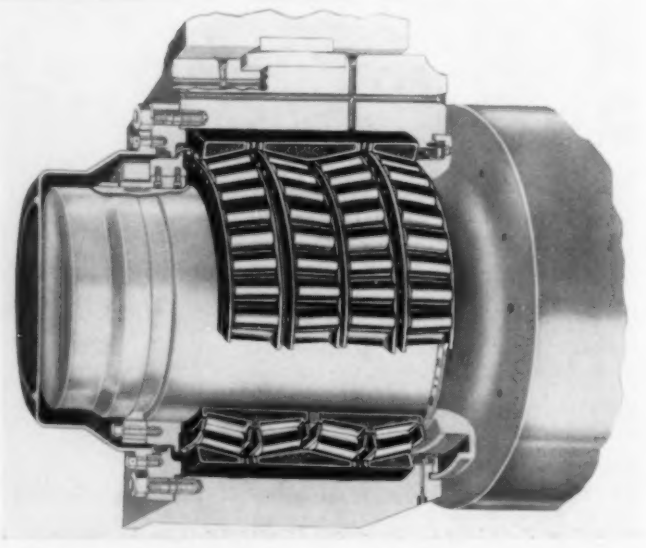
▲ DUE to the great amount of interest shown by the rolling mill industry in higher rolling speeds, it was evident that the industry required a heavy duty type mill roller bearing which could be applied on mill roll necks with an interference fit. Such interference fits would eliminate neck scuffing which occurs quite frequently when loosely fitted bearings are operated under high loads at high speeds.

Although there is some roll neck and cone bore scuffing, when loosely fitted cones in 2-row and 4-row type bearings are used in low speed mills, no particular difficulty is encountered during the life of the roll. However, when heavy rolling loads are combined with high operating speeds, the roll neck and cone bore scuffing increases rapidly due to the higher slippage velocities between the roll neck and cone bore. Attempts have been made to provide positive lubrication between the roll neck and cone bores by rifle drilling the necks and installing suitable lubricant connections. This has retarded and reduced the scuffing but is not considered as the answer for use at the high operating speeds encountered today.

It has been known that 2-row double cone, bore, bearings when applied with tight cone fits provide an ideal mounting for precision wire and strip mills. However, a straight bore bearing is rather difficult to remove and for installations where the bearings had to be removed rapidly, 2-row double cone tapered bore, bearings were developed. This type bearing has not only been used in many installations such as bar and rod mills, but in many other applications, including the paper, rubber and plastics industries as well.

Ten or fifteen years ago, a 2-row type tapered bore bearing was considered entirely satisfactory for high speed rod mills both from the standpoint of mounting and capacity. However, due to the present day practice of rolling three and four strands simultaneously instead of the one or two strands which were rolled a few years ago, the loads on bearings have increased materially. This obviously calls for greater capacity bearings for high speeds for which a tapered bore 4-row type bearing appeared necessary.

Figure 1 — The balanced proportion bearing was designed to minimize stress concentrations.



The requirements for greater capacities at higher speeds of temper pass and cold reduction mills also encourage the development of the 4-row tapered bore bearing.

Before going into the details of this new development by our company, it may be well to refresh our minds on some of the details around the use of standard loose fitted type 4-row tapered bearings which have been in use for many years on main roll neck as well as work roll necks on both low and medium speed mills.

Figure 1 is a cut-away section through a "balanced proportion" 4-row bearing applied with loose fits on the inside races as well as the outside races. These 4-row bearings have their outside races separated by means of cup spacers and the two inner races by means of a cone spacer. These spacers are properly ground for the amount of bearing looseness which is required of the particular mill operating conditions. The cups or outer races are clamped in place in the chuck by means of a suitable cup follower secured by means of a series of cap screws. The cones, or inner races, are held in place on the neck by a cone follower located by means of a suitable locking device. The most conventional locking device used at the present time consists of a nut applied over a split threaded ring which is located in the groove on the roll neck extension. The cones are properly positioned by clamping the nut tight against the clamp ring and then backing it off from $\frac{1}{6}$ to $\frac{1}{4}$ revolution, after which it is locked in place.

We apply the inner races with a loose fit of approximately 0.0005 in. per in. of neck diameter and provide lubricant slots adjacent the bearing cones on the clamp ring, fillet ring and cone spacer. The slight creepage of the cone on the neck will draw lubricant through these slots into the clearance between the bearing bore and the neck outside diameter through these slots. The faces of the fillet ring and clamp rings, as well as the faces of the cone spacer for this bearing are hardened in order to assure long life.

In such cases where some difficulty is experienced with neck scuffing on high speed mills, provisions have been made to lubricate the surfaces between the cone bore and the neck outside diameter by properly drilling holes through which lubricant can be applied constantly. In most cases of slower speed mills the application of lubricant to the neck when the bearing was assembled on the neck seemed to be entirely satisfactory.

Figure 2 shows a cross-sectional assembly involving a mill roll with the bearing appiled at each end. It will be observed that the chuck is fixed to the mill housing on one end and is permitted to float on the other end. In installations such as foil mills and high speed cold reduction mills, where the rolling is done on the stretch of the mill, a considerable amount of expansion and contraction occurs from temperature build-up from the rolling pressures. It is obvious that a considerable amount of resistance to freedom for the bottom roll chucks to float in the windows is developed due to the coefficient of friction between the chuck and the base of the window. Therefore, besides the radial loads that are imposed on the bearings, a certain amount of thrust which might, in some cases, be as high as 25 per cent of the radial load might also occur. In working out the ideal bearing design and its mounting which might be suitable for high speed mill service in which higher operating temperatures might normally develop, it seemed desirable to provide a mounting which would offer the least resistance to axial movement for this floating chuck. Instead of working this into the chuck design and its support in the housing entirely, it developed that a rearrangement of the tapered rollers within the bearing might prove advantageous. Therefore, after

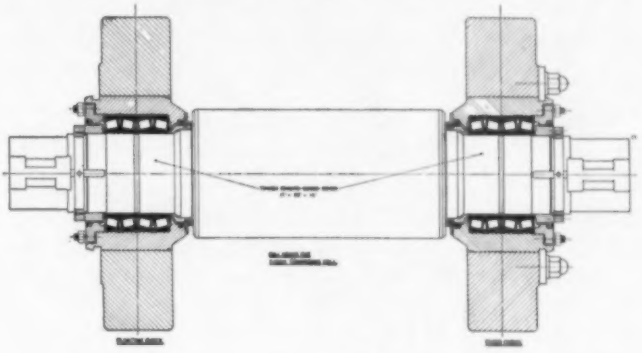


Figure 2 — Sketch shows typical assembly for a strip mill.

many possible mountings and bearing designs were investigated, the design, which follows, was finally adopted. This design showed many advantages which had not previously been used in mounting tapered roller bearings on mill roll necks.

Figure 3 shows the application of this new type 4-row tapered bore bearing mounted in a chuck and clearly shows the rearrangement provided for the rollers within the bearing over that previously shown for the standard type 4-row bearing. The bearing assembly consists of four rows of rollers with the outer rows arranged indirectly to permit maximum neck diameters and improved load distribution over all the rollers in the bearing. Two double cups and one cup spacer make up the parts that fit into the chuck bore. The inner races which are applied to the roll neck consist of two

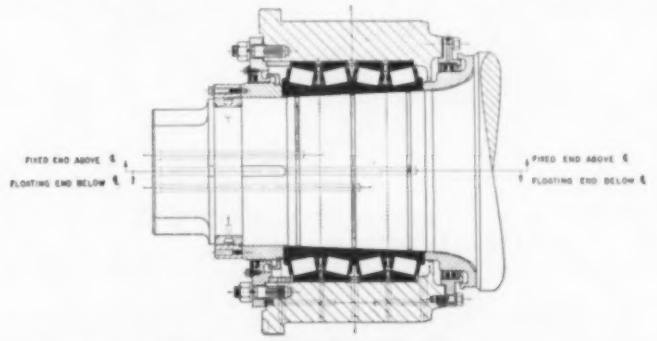


Figure 3 — New type bearing permits maximum neck diameter and gives improved loading distribution over rollers in the bearing.

single row inversely tapered bore cones at the ends and one double tapered bore cone mounted between them.

In referring to the figure it will be observed that the inner races are clamped against a fillet ring which is applied with a light press fit on the roll neck. These races are held in place through a cone follower and wide locknut fitted over a split threaded ring.

Figure 4 shows that the outer races are clamped

through the cup follower on the left hand end of the roll thus fixing the roll to the chuck. On the right hand end of the roll, a clearance is shown between the cup face and chuck face on the inside and between the cup face and the clamp sleeve on the outside. It is customary to fix the roll on the operating side and permit the bearings on the drive side of the mill to float. At the same time, the chuck should also be free to float in the windows. This mounting gives us a unit box through the flinger applied to the clamp ring on the outside and through the radial extension of the chuck riding with a close clearance on the outside diameter of the fillet ring at the inside.

These bearings, which have a taper of 1 in. per ft on diameter, are applied with an interference fit of approximately 0.0005 in. per in. bore. On some of the first installations, a lighter fit than the above was used due to the uncertainty that still existed at that time on the amount of pressure required to press these bearings up on the taper in these large bores, and the amount of difficulty that might be experienced in removing them from the tapered necks. Experience to date indicates that it will be possible to obtain this fit without difficulty, thereby giving added assurance that the bearing cones will not tend to creep in service. Oil grooves, having a depth of approximately $\frac{3}{64}$-in are provided in the roll neck at the center of average radial pressure for each of the three cones. Oil will be applied to these grooves when removing the bearings from the necks.

Bearing lubrication is supplied through holes leading to the double cups. In the event that a circulating oil

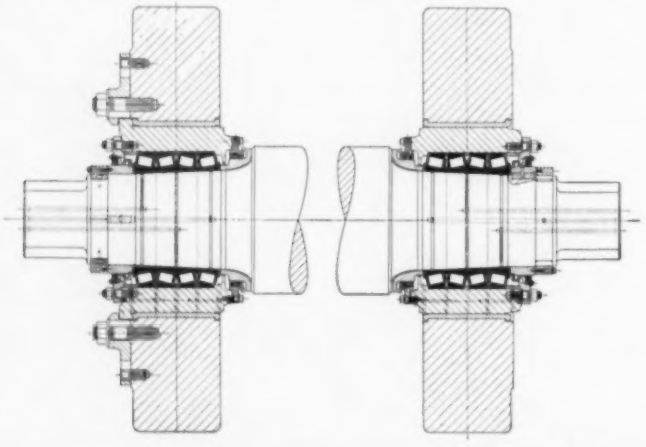


Figure 4 — Outer races are clamped through cup follower on the end of the roll.

system is used, oil drains are provided to the cup spacer located between these double cups and through drains located at each end of the chuck adjacent the bearing.

Proper endplay is built into the bearings by grinding the cup spacer between the two double cups and by selecting roller sizes for each of the other two positions. The endplay that is provided for the bearing when it is manufactured is established by adding the amount of desired assembled endplay to the amount lost during cone expansion when the bearings are pressed on the neck.

These 4-row tapered bearings provide maximum capacity combined with interference fits of the inner races, thereby assuring long roll neck life and maintenance of mill setting. In spite of the interference fit between the inner races and roll neck, the arrangement of the mounting as shown still permits the installation and removal of the bearing and chuck as an assembly in a matter of minutes, without removing the bearing from the chuck. This installation and removal can also be accomplished without contamination of the lubricant within the bearing assembly.

Figure 5 shows the location of a ring gage on the roll neck in order to determine the length of the fillet ring

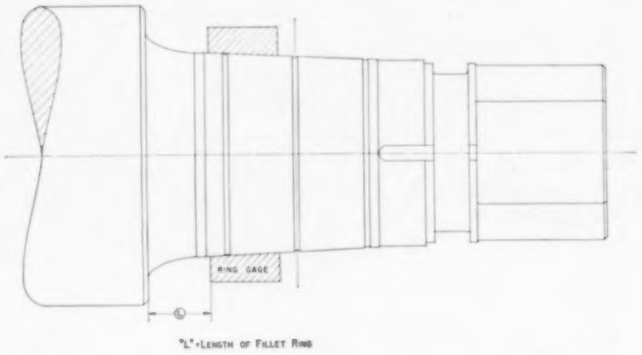


Figure 5 — Sketch shows use of ring gage on roll neck in order to determine length of fillet ring required.

"L" required between the mill roll barrel and the stopping point against which the bearing cones will be pressed. The inside diameter at the inside face of this ring gage is made greater than the inside diameter of the bearing cone by an amount equal to the interference fit which is desired between the cone bore and the neck outside diameter. This checking system assures accurate fillet ring lengths in order that all roll necks will be made interchangeable for use in connection with any interchangeable bearing that is supplied. This interchangeability is made possible by an entirely new method of match grading the tapered bearing bores when they are manufactured. In other words, the bearing cone bores are held to a tolerance of zero to plus 0.00015 in. After the fillet ring length is properly established, it is press fitted to the roll neck and then remains as a permanent part of the roll neck thoughout the mill roll life. When the roll is discarded and has served its useful life, the fillet ring may be used on another roll by re-establishing it on a new neck as long as the fillet length "L" is not shorter than the required space "L" as measured with the ring gage in place.

An annular piston type hydraulic jack which is threaded over the split threaded ring is used to press the bearings up the taper of the neck. This was developed to press the bearing chuck assembly in place as a unit assembly. Numerous tests were conducted in the laboratory and checked in actual field installations to determine the forces required to press the cones up the taper of the necks with various interference fits. It is recommended that all lubricant be removed from the neck outside diameter and if possible from the cone bores before the cones are pressed in place.

The size of the hydraulic jack must be designed to provide sufficient capacity to press the cones on the dry necks. The jack size is determined by the selection of the piston area required for use with the available oil pressure. Any commercial hydraulic pump capable

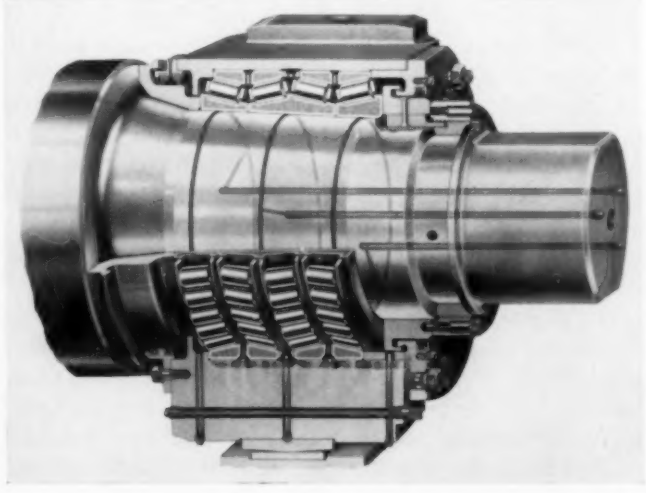
Figure 6 — This small hand pump will generate the necessary capacity to press up practically all tapered bore bearings.

of supplying an oil pressure of approximately 8,000 psi will be satisfactory. Experience indicates, however, that a well proportioned jack can be built to apply 4-row balanced proportion bearings with the desired interference fit without exceeding a pressure of from 5000 to 6000 psi.

In the tests conducted to date it has been found that a chevron type composition seal works out quite satisfactory.

Figure 6 shows a hand pump which will generate the necessary capacity in pounds per square inch to press up practically all tapered bore bearings with the required interference fit. However, due to the volumetric capacity of the holes that are sometimes necessary in the larger bore bearings, a power driven pump will deliver the required amount of oil more rapidly and bring the line up to pressure more quickly. Such a pump is an economical unit which has been very practical—not only to supply the pressures required in pressing the bearing up the taper, but also in the use of the hydraulic method of bearing removal. For large mill installations requiring larger hydraulic lead holes, higher volumetric capacity pumps are desirable and are recommended.

Figure 7 — Phantom view shows bearing applied to tapered neck.



DISASSEMBLY PROCEDURE

Figure 7 is a phantom view of the bearing applied to the tapered neck, clearly showing the rifle drilled holes connected to the three radial holes leading to grooves under the outer, center and inner cones, respectively. The oil groove around the neck outside diameter for each race is located at the neutral pressure zone for each cone section. For the single cones at either end of the assembly, this groove should be located in a plane which will pass through a point on the roll and cone

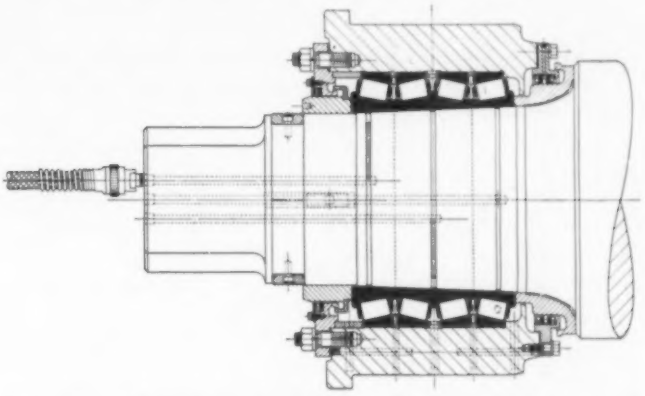


Figure 8 — View shows hydraulic line applied to the No. 1 hole which leads to the outside cone.

contact line which is located away from the cone rib a distance of about 33-⅓ per cent of the roll and cone contact line length.

Figure 8 shows a hydraulic line applied to No. 1 hole which leads to the outside cone. The mill roll, with bearing and chuck assemblies, should be supported on

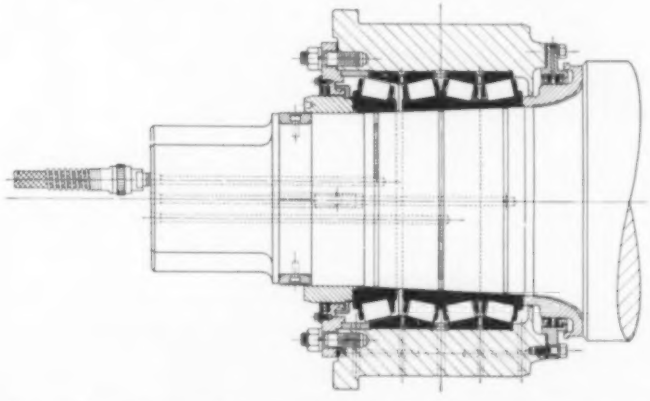


Figure 9 — As the oil pressure is applied, the cone expands and the actual pressure forces it from the neck.

the roll barrel outside diameter being certain that the chuck does not carry any of the mill roll weight. Figure 9 shows the first stage of the disassembly process. When the oil pressure is applied, it will expand the cone while the projected axial thrust pressure will force it from the neck. This removal is permitted through the hori-

zontal clearance which was provided between the flinger face and the cup follower.

Figure 10 shows the second stage of removal. The hydraulic pump is connected to the axial oil lead which

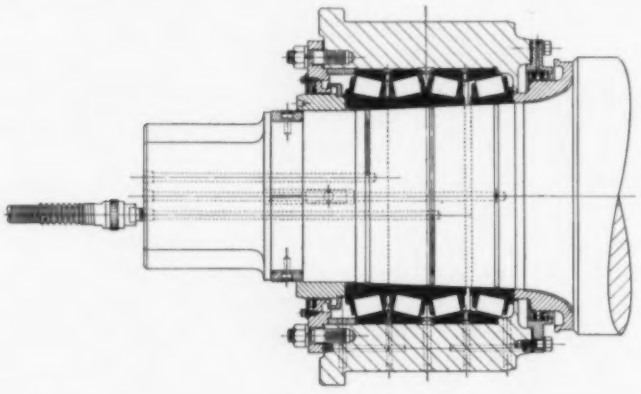


Figure 10 — In the second step, the pump is connected to the oil lead going into the groove under the center double cone.

intersects the radial hole leading to the groove under the center double cone. The oil pressure is applied to expand this cone and force it from the neck. This was permitted by the movement of the entire chuck assembly. Since the inner cone is still tight on the neck, the clearance originally found between its backface and the adjacent chuck inside face has been closed as shown. Figure 11 shows the last stage. The hydraulic pump is connected to the axial oil lead which intersects the radial hole leading to the groove under the inner cone which is still on the neck. Oil pressure is applied to expand this inner cone and force it from the neck. The bearing and chuck assembly may now be easily removed

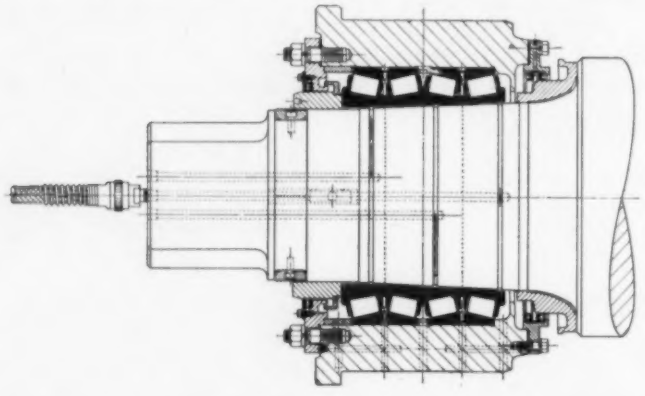


Figure 11 — In the last step, hydraulic pump is connected to the oil lead which goes into the groove under the inner core.

as a unit. The release of each cone can be readily detected by both sound and touch because of a light bump emanating from the chuck.

It is to be noted that this complete bearing assembly is a closed box arrangement and makes it possible to remove the unit from one neck and place it on the other without contamination of lubricant which may be within the bearing. In the case of circulating oil systems, a small oil level may be maintained by properly locating the oil drains to maintain any level desired. Tests seem to indicate that a groove depth of only $\frac{1}{64}$-in. would actually be satisfactory; however, we have recommended that a groove depth of approximately $\frac{3}{64}$-in. be used in order to assure pressure flow of the hydraulic media around the large neck outside diameters. This is especially needed if at some future date it may be necessary to actually use grease as the pressure media to assist in removing cones that might tend to adhere to the neck due to accidental cases where foreign particles might get lodged between the cone bore and the neck outside diameter. We have found that the width of the groove should vary somewhat with the size of the neck and for all practical purposes we consider a $\frac{1}{8}$-in. groove width satisfactory to a 6-in. diameter, a $\frac{1}{4}$-in. groove to 12-in. diameter, a $\frac{1}{2}$-in. groove to 24-in. diameter and a $\frac{3}{4}$-in. groove to 36-in. diameter. We are sure, however, that these groove widths could vary somewhat either above or below this figure and still be perfectly satisfactory.

Attention should also be called to the fact that it is possible to take these bearing and chuck assemblies from the necks without touching the cap screws or cup follower or assembly in any fashion, so that changes from one roll neck to another roll neck can be made with the least amount of delay.

COMPARISON OF DESIGNS

In reviewing the above, it will be noted that this bearing design and arrangement for mounting has some very outstanding features. It is an easily serviced mounting using interference cone fits and meets all requirements for high speed mill operation by entirely eliminating neck scuffing and wear. The interference cone fit will provide greater stability between the cone and the neck and will give better load distribution not only between the four rows of rollers in the bearing but also to the various rollers within each row. This easily serviced installation permits improved fillet contours and larger necks with the resultant lower neck stress and deflections over any other arrangement that can be used.

By using a floating cup mounting on one end, we get more freedom for expansion of the mill roll on the drive end to assure longer bearing life. At the same time, installation of the chucks into the mill housings is not changed since the chucks are also permitted to float in the windows of the housings. During the warm-up period when a mill is first started up, either cups or chucks or both may float. However, after the chuck has found its location in the window, any subsequent contraction or expansion will be provided by movement through the cups only.

It should be of interest to know that in January 1953 one installation with these bearings was made in a mill in Portsmouth, Ohio. The bearing has a 20-in. bore, 27.375-in outside diameter and 17.750-in. width and is used on a 31 x 56-in. 2-high temper pass mill. Approximately 2500 psi pressure was needed to press the bearing to the neck by means of the hydraulic ring jack. An equal unit pressure was required to remove the center

double cones, whereas 1400 psi and 2100 psi were required for the inner and outer cones, respectively. Another installation made in February 1953 is now in service at Cleveland, Ohio. This is a 21 x 56 x 72-in. 4-high temper pass mill using a bearing having a bore of 32.625-in. an outside diameter of 45-in., and a width of 32-½-in. Two additional 4-high mills, 15 x 55 by 72-in., will be in service in 1953 using a bearing 21.5625-in. bore, by 29.995-in. outside diameter by 23-⅝-in. width. Recommendations have been made for a large number of other installations which will probably develop as contracts sometime in 1953.

TAPERED ROLL NECK GAGING

Tapered roll necks are currently measured for both taper and diameter by means of a sine bar gage. This gage is placed on the tapered roll neck as shown in Figure 12. One of the hazards of this method lies with the difficulty of accurately aligning the gage with the roll axis. It will be noted that micrometers are used to

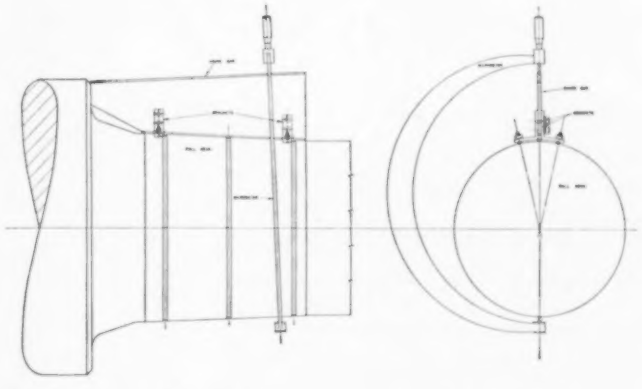


Figure 12 — The sine bar gage previously was the common method of measuring a diameter.

check the diameter and taper by measuring the distances from the edge of the gage to the outside diameter of the taper of the neck at 180 degrees to the gage. By checking these dimensions at three or four zones, the taper and diameters may be readily established. The second hazard rests with the ability of the man handling the micrometers. This is especially true in the larger neck diameters where measurements may range from 30 to as high as 40 in.

Since an improved measuring system appeared desirable, a careful study of the problem developed the possibilities of using some form of straddle gage which could be assembled with either indicators or adapted to air gaging principles to obtain a more accurate measuring system. This appeared quite feasible by setting the gage to a master and then using it as a comparator gage.

After thoroughly analyzing these possibilities several gage manufacturers were invited to submit their proposals. In contacting a company at Philadelphia, Pennsylvania, our company recommended that they incorporate the air gaging principle to their proposals. It has since been revealed that this gage is accurate within 0.0001-in. on diameter and will show variations in taper as well as diameter. Its use also eliminates the need of a ring gage normally required to determine the fillet ring length.

Although the possibilities for checking the roll neck diameters within a matter of a few ten thousandths of an inch for diameter and taper accuracy is available, this does not imply that it is necessary to actually hold these mill roll necks to the tapers within the accuracy of the gage. It does, however, show you quite accurately what variations exist on the roll necks on which these bearings will be applied. We have found that it is possible to hold our cone bores to approximately 0.0002-in. to 0.0003-in for taper even in the larger sizes. Experience has indicated that the manufacturers of the rolls for the large 32-⅝ in. bore bearings have easily been able to hold the tapers on these necks to within 0.001-in.

Figure 13 shows this new air gage applied to a 32.625-in. neck. It is a two-saddle type using two gaging frames. It is called a pneumatic comparator gage and commonly referred to as an air gage.

To date, one company has built two of these gages for us. One of these air gages will check tapered roll necks from 20 to 34-in. large end diameter; the other air gage will check tapered roll necks from 3 to 6-in. large end diameter. It is probable that a third size will

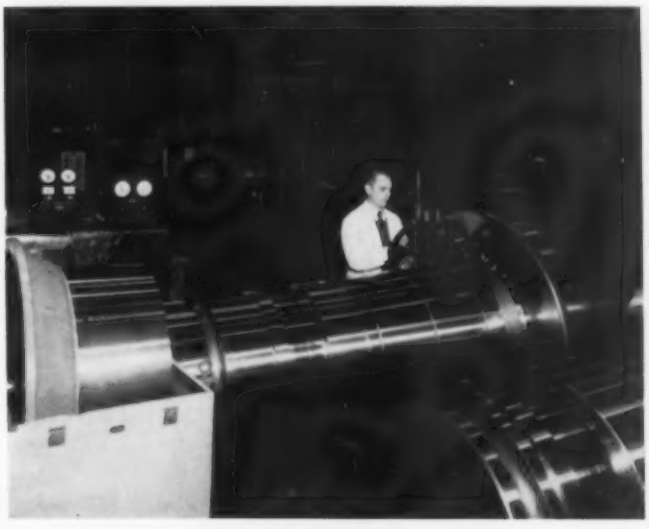


Figure 13 — The new air gage is shown applied to a 32.625-in. neck.

meet the requirements from 6 to 12-in. while a fourth will measure necks from 12 to 20-in. Therefore, the entire range of necks from 3 to 34-in. will only require four sizes, as long as the taper of one inch per foot, the taper of our present bearing bores, is maintained.

This new gage developed for the rolling mill industry assures mill builders that tapered roll neck dimensions can be determined to such a high degree of accuracy that *all* tapered roll necks with their matched fillet rings will fit interchangeably with all our new tapered bore, 4-row bearings.

The *basic* function of this new air gage is to compare the size and taper of a tapered roll neck to a master which has been made to the exact basic diameter and taper required.

CONSIDERATIONS IN THE DESIGN OF PLAIN BEARINGS

By A. E. CICHELLI
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. . . . a good theoretical background in bearing design may not give absolute answers but will allow the designer to evaluate and compare different designs and investigate effects caused by changing certain variables . . . .

▲ IT has been characteristic of this Association's progress and development that, one by one, the technical practices throughout the industry have been assembled together, analyzed for the preferred trends, and finally summarized into what most of us know as the AISE Standards. Among the fields to be explored for this purpose was that of plain bearing design, installation and maintenance. All of you, undoubtedly, are familiar with the very commendable pamphlet, entitled "Plain Bearing Recommended Practice" issued July 1951. Originally it was intended to set standards, as was done in nine previous studies in other fields, but the committee wisely refrained in view of the wide variations in operating conditions existing in the industry. Nevertheless, the Bearing Practice, as they were called, contain a large volume of data and information pertaining to the subject, which if made use of, would prove extremely valuable to plant engineers. After a one-year trial, it was designated AISE Standard No. 12. It may be obtained from the headquarters of the AISE.

It has been the thinking for a long time that while a ready reference on installation and maintenance practices was desirable, it was perhaps even more important in the long run, that sufficient theoretical data be offered to induce steel men to employ an engineering approach to the solution of their plain bearing problems. The committee believed, and we concur, that many of the problems that exist throughout the industry could be solved more accurately, and in many cases more expeditiously if reliance were placed in the theory and less in the wild guesses that often take place. Furthermore, we believe improvements could be made in many cases where the field considers there is no problem at all.

A study of the committee's report will disclose how well it handled a difficult assignment.

Our purpose in this paper is very simple. In effect, it serves as a follow-up to the Recommended Practice, and

is essentially an attempt to go a little further in this matter of engineering approach. We should like, with your permission, first to review some of the background theory and principles; then to apply them to a typical steel mill bearing problem. Reference will be made to data in the "Practice" as well as to some new, recently published, working charts by Messrs. Boyd and Raimondi of the Westinghouse Research Laboratories, which with modifications might eventually make valuable additions to the Practice.

These charts were published by Messrs. Boyd and Raimondi in the "*Journal of Applied Mechanics*" in September 1951 and were included in a paper entitled "Applying Bearing Theory to the Analysis and Design of Journal Bearings."

When an engineer in the field is faced with a plain bearing problem, he finds there are many definite characteristics of that bearing he would like to be able to predict. He would like to know, for example:

1. How much load it will carry under definite conditions of speed and oil viscosity?
2. What oil should be used for a prescribed load?
3. Where should the oil be fed and how much is necessary?
4. At what temperature will it run?
5. Where is the actual load line?
6. Where is the position of highest film pressure and what is it?
7. How many horsepower are required to overcome friction?
8. Can anything be done to reduce friction?
9. What should the correct bearing clearance be to be satisfactory at the operating conditions?
10. What effect, if any, will changing speeds and/or loads have on the operation of the bearing?

These are very plausible questions, and thanks to the work of many contributors to this particular branch of research, very good approximations can be made, despite the labor involved in the task. Nevertheless, the Boyd-Raimondi charts, developed by solving the mathematics of the more generally accepted theories, seem to be an excellent means to circumvent this tedious work.

Once you have had an opportunity to compare the ease of using them with the complicated equations from which they originated, you will agree. Our main interest, at this time, is, just how adaptable are they for our purpose.

Mere mention of the word "theory" normally exacts a groan from the audience, imperceptible though it may be. And the real reason is that most of us have not given more than a casual glance or two at the technical mathematics associated with our work — from the day our formal schooling ended. This state of affairs is especially true in the instance of steel mill engineers who are beset with so many other pressing problems that for many there are not enough hours in the day.

Assuming we have made a reasonably accurate appraisal of conditions as they exist at the moment, we shall do our utmost to keep our subject down to earth. On the other hand, since every principle stated can be shown also as a mathematical expression, though approximate in some cases — we believe you should at least see them and be thankful you were not required to make derivations in the first place.

Plain bearings are those, which in supporting an applied load, are in sliding contact with that load. In each case, the bearing depends on a full fluid film of oil under pressure for carrying the imposed load. There are seven principal classes of these bearings listed as follows:

1. Thrust bearing, externally pressurized.
2. Thrust bearing, pivoted shoe.
3. Floating pad bearing.
4. Thrust bearing, parallel surfaces.
5. Full floating bearing.
6. Full journal bearing.
7. Partial journal bearing.

This paper will be confined, where possible to the partial bearing, oil lubricated group.

Figure 1, based on an illustration appearing in the Boyd-Raimondi paper, gives the nomenclature that will be used throughout this paper.

Starting with first things first, let us take up the concept of friction. Friction force is to be distinguished from the coefficient of friction. When two objects are in sliding contact with each other, the amount of force required to cause one to slide over the other is called the friction force. It is equivalent to the restraining force which in turn varies in magnitude, depending on the nature of the material surfaces, the area of contact, and

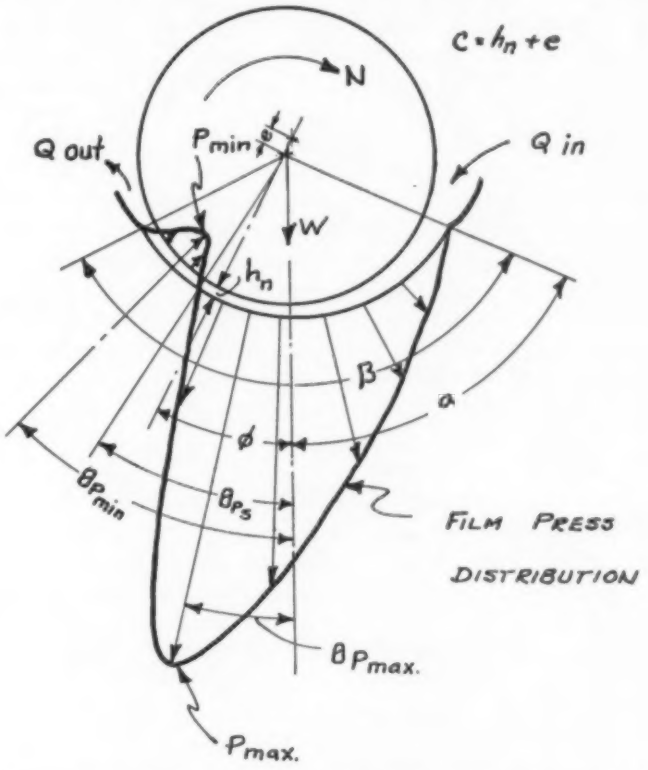

Figure 1 — Sketch gives nomenclature used in this paper.

the nature of any fluid that might be in between. When this force is divided by the applied load acting perpendicular to the line of motion, the result is known as the coefficient of friction. Petroff, in 1883, was able to evaluate the friction force in a bearing, recognizing that it was a viscosity problem, primarily. Figure 2 will show the correlation as developed by him between friction, load and horsepower loss due to friction. This illustrates useful fundamental equations, but can only be considered approximations for the heavily loaded bearing.

$$F = 0.658\left(\frac{\mu A^2 L N}{C}\right)$$

$$f = \frac{F}{W} = 2\pi^2\left(\frac{A}{C}\right)\left(\frac{\mu N'}{P}\right)$$

$$HP = 10.44 \times 10^{-6}\left(\frac{\mu A^3 L N^2}{C}\right)$$

F = friction force - lbs.
A = journal Rad. - in.
L = bearing length - in.
μ = viscosity (reyns)
N = R.P.M.
N' = R.P.S.
W = total load - lbs.
$P = \frac{W}{2AL}$ = P.S.I.
C = Radial clearance

Figure 2 — Fundamental Petroff equations for bearing design go back to 1883.

Later on it will be seen that this friction force is also a function of the eccentricity of the journal.

Figure 3 demonstrates the four kinds of sliding friction phenomena encountered. The highest friction coefficient obtains when two dry clean surfaces are brought together in sliding contact, in which case the coefficient of friction may be as high as 6.0. The second class of sliding contact is normally referred to as extreme boundary, wherein the restraining force is somewhat less than exists between two dry surfaces, but somewhat greater than if there were a fluid completely separating them. In such cases, a fluid is present, but not with sufficient internal pressure to keep the surfaces apart entirely. The peaks of one surface become obstructions in the path of peaks on the other surface. The coefficient of friction in these instances is in the order of 0.5 and is caused by the friction force required to shear away the high spots. The introduction of chemically active agents in the fluid serves to hold this force down by forming low shear strength metallic compounds which shear off at the high spots with less force required. These extreme boundary lubrication aids will work so long as temperatures higher than the melting point of the metallic film do not occur to render them useless.

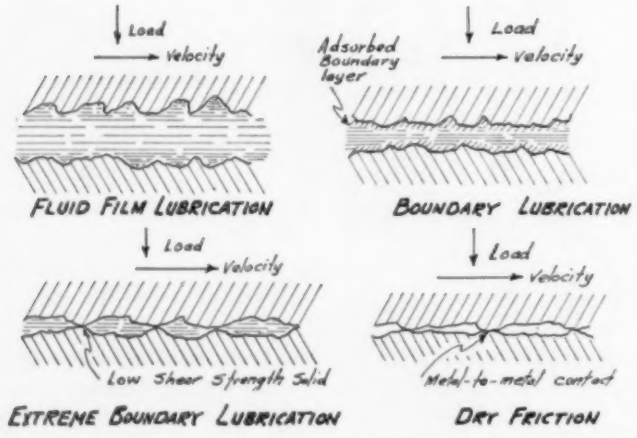

Figure 3 — Sketch shows four common kinds of sliding friction.

The third class of sliding contact friction is that which exists when two surfaces are completely separated, but not to such an extent that a minimum friction coefficient has been reached. In such cases, the coefficient ranges between 0.05 to 0.1. Here it is believed that surface finish, and chemical and physical properties of the surface of the lubricant have a greater influence than oil viscosity on friction. In this region, known simply as boundary lubrication, it has been observed that the presence of polar compounds adsorbed to the metal surfaces prevent metal to metal contact, but only function at moderate loads and specific temperatures (depending on the organic material used).

The final category of sliding contact friction is the one in which the two surfaces are completely separated by a bulk layer of lubricant — preventing thereby any solid contact from taking place. Under these conditions, the oil film thickness is in the order of thousandths of an inch or less. Even so, when compared with a molecular layer, it is quite large. (Kingsbury is reported to have operated a bearing satisfactorily with a film thickness of only 0.0000025 of an inch). Lubrication of this type is ideal, and with uninterrupted operation, can be expected to eliminate wear entirely. It is only during starting and stopping periods, when the film thickness

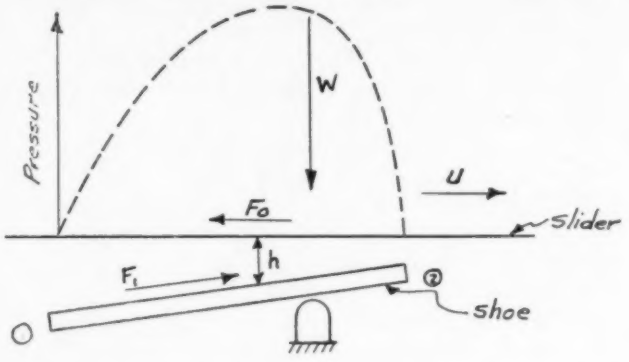

Figure 4 — Theory of slider bearing is normally extrapolated to circular bearings.

is nil, that wear can occur with this type of lubrication. A full-fluid film, such as fulfills the requirements of this class, effects a reduction in both heat and friction, since the only source of heat would be in the oil film itself. The coefficient of friction can be well under 0.005 in. up to about 0.1 in. in this group.

The mechanism for the establishment of this film may be understood better if reference is made once more to Figure 1. Pumping is induced by the fact the journal center is eccentric with the center of the bearing so that on one side of the journal the oil is dragged into a converging wedge, while on the discharge side the oil leaves in a diverging, expanding wedge.

Since the thickness of the film is so small in relationship to the length of the bearing arc, it is safe to analyze further the mechanism of this phenomenon by considering it to be similar to the slider bearing — shown on Figure 4. It will be observed that as in all hydraulics, in order for the same quantity of oil to pass points 1 and 2, it is fundamental that the velocity and pressures are necessarily greater at 2 than at 1. As liquid is pulled through by the moving plate, there is a tendency for the liquid to back up in the wedge, but since liquids are incompressible, pressure develops in this region instead — and incidentally, simultaneously causes side leakage.

This principle can be demonstrated very easily in the laboratory, not only on a plane surface, but also on a curved surface as in a journal bearing.

It is obvious, the geometry of the wedge, the speed

of the moving member, and the characteristics of the lubricant, determine if and how much pressure is developed.

In a journal bearing (refer again to Figure 1), the relative position of the journal with respect to its bearing determines the converging wedge angle. That, coupled with the speed and oil viscosity, can be used as a criterion for determining how much load a bearing will carry.

There are two expressions widely used for solving bearing problems. Both are discussed in detail in the AISE Bearing Practice so that a full repetition here would be superfluous. However, a brief reference to, and an explanation of, their meaning, would, we believe, be in order at this time.

First, let us take the expression ZN/P. To the initiated, this is a very useful quotient, giving a picture of a bearing's condition. The ZN/P ratio has a range from zero to over 200, when using Z in centipoises, N in rpm and P in psi, the average unit load per projected area. But a ZN/P that may be suitable for one type of bearing is not satisfactory for another type. Experience has shown that different bearing services require ZN/P ratings within certain limits for each particular type.

Figure 5 illustrates how coefficient of friction varies with ZN/P. A decrease of ZN/P for any reason is accompanied by a decrease in "f" up to a certain point, after which it rises rapidly with continued decrease in ZN/P. This sort of curve was to be expected as it fits in closely with the concept of sliding contact given earlier.

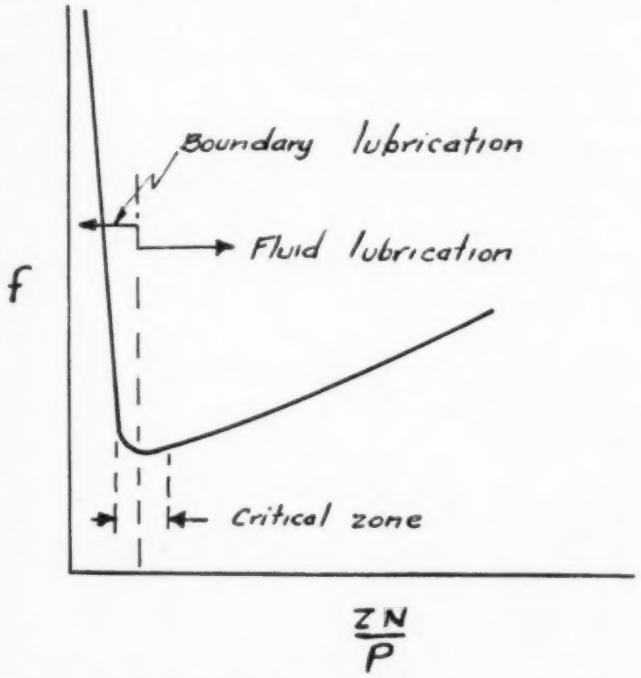

Figure 5 — Coefficient of friction varies markedly with the ZN/P ratio.

Of real interest is the fact that despite the presence of bearing clearance in most of the mathematical expressions, the ZN/P vs "f" curve ignores it entirely, (except insofar as it assumes commercial clearances). These unfortunately are not accurately defined. The influence and importance of radial clearance can be noted from Figure 6. Although somewhat exaggerated, it is intended to illustrate the difference in wedge action present in a bearing with large radial clearance, compared with another with much less radial clearance. In effect, the pressure zone required to carry the load is reduced. Should the angle be wide and very large, the load would be carried by a very narrow band, and hence would be higher per unit area. This could very likely result in early failure. On the other hand, a very low radial clearance would at the same time have a more acute converging angle — having the effect of increasing the area carrying the load while simultaneously reducing the peak pressure (required to carry the load). ZN/P studies do not take this matter into account.

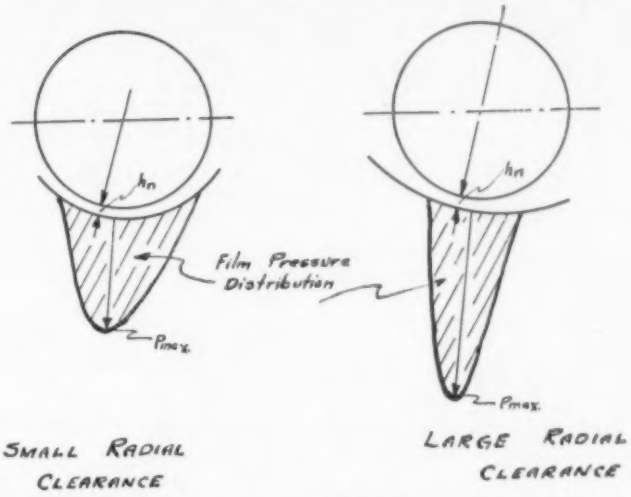

Figure 6 — Large clearance ratios increase pressure on bearing.

Its counterpart, the Sommerfeld number $(R/C)^2\mu\ N/P$ does so, and for more accurate results seems to be the better criterion. You will observe the expressions are identical but for the ratio, $(R/C)^2$.

In a moment, we shall proceed with our example, but before we do, let us refer once again to the bearing questions that arise in an engineer's mind.

As to how much load will a bearing carry, an answer can be found in the solution of Reynold's differential equation in three dimensions which, when solved, will give the pressure in the oil film at any point, while simultaneously taking side leakage into account. The basic equations will be seen in Figure 7, having been solved by Kingsbury and Sommerfeld. They concluded and could demonstrate that there was a particular film shape for each type bearing for which the coefficient of friction was a maximum. This conclusion led to the concept of load-leakage and friction-leakage factors introduced by Kingsbury. They are defined as the ratio of loads for a finite length to an infinite length bearing, respectively, that would produce equivalent film shapes. It was observed further that a plot could be made of these leakage factors against L/D of the bearing.

Figure 7, has an expression for a journal bearing's load capacity (neglecting end leakage). Note the appearance of the Sommerfeld Number on the left hand side of the equation, and consequently the importance of clearance.

The shape of the oil-film pressure curve resembles a parabola leaning in the direction towards the point of minimum film-thickness.

The question of peak pressure in the film is a matter

for concern, insofar as the bearing material itself must withstand local high loading. A ratio of 3 to 1, peak load to unit load, has been considered satisfactory and safe by some authorities.

The second important question refers to the selection of the oil. The criterion for the selection shall be minimum friction, maximum load capacity, minimum film temperature rise or a compromise. Both ZN/P vs "f" and S vs "f" show a minimum point in the friction curve. This point represents definite border line conditions and an increase in viscosity or speed, or a decrease in the

GENERAL EQUATION — REYNOLDS

$$\frac{\partial}{\partial x}\left(\frac{h^3 \partial p}{12\mu \partial x}\right) + \frac{\partial}{\partial z}\left(\frac{h^3 \partial p}{12\mu \partial z}\right) = \frac{U \partial h}{2 \partial x}$$

REYNOLDS — (SPECIFIC)

$$\frac{dp}{dx} = 6\mu U\left(\frac{h - h_1}{h^3}\right)$$

SOMMERFELD'S SOLUTION

$$P - P_0 = \frac{6\mu U}{c^2}\left[\frac{n(2 + n\cos\theta)\sin\theta}{(2+n^2)(1+n\cos\theta)^2}\right]$$

$$\left(\frac{r}{c}\right)^2 \frac{\mu N'}{P} = \frac{(2+n^2)\sqrt{1-n^2}}{12\pi^2 n}$$

Figure 7 — Basic equations for the solution of Reynold's differential equation are here given.

load would shift the position to the right on the curve where lubrication is more stable. A decrease in clearance would have a similar effect. The proper oil to use then is one that will keep the bearing in the hydrodynamic region, throughout the complete range of operating speeds and loads, giving rise at the same time to a temperature increase that would be safe for the oil and materials.

A knowledge of clearance and minimum film thickness is necessary and from this it is possible to work back to the Sommerfeld number and then solve for the viscosity.

As for temperature rise expected in a bearing, we find this to be a troublesome question in view of the difficulty in accounting for all the heat losses by conduction, radiation, and some convection. However, one authority has suggested a method of solution by relating the hydrodynamic equilibrium with thermal equilibrium. A means was developed for plotting a curve giving the safe load corresponding to any bearing speed at a maximum allowable temperature. The authors of this scheme are S. A. McKee and T. R. McKee, who developed the theory in 1929, presenting it before the ASME. Further exploration of this scheme is desirable, but not within the scope of this paper.

It is erroneous to convert all the friction horsepower to heat and eventually temperature rise. As might be expected, the latter is influenced simultaneously by both friction and flow, varying directly with friction and inversely with flow.

The Boyd-Raimondi charts demonstrate this point very well. However, their temperature rise variable assumes that all the heat generated remains in the oil, with no losses to be considered and that the oil goes through the bearing once without recirculating. Actually then, this figure represents a limiting value of temperature rise, its upper limit.

The next question deals with the quantity of oil and the point of application. From a glance, again, at Figure 1, it is obvious oil should be fed ahead of the load zone. What is more important is to locate the line of action of the load and then follow up with a study of the film pressure distribution curve. The latter data can be obtained from Reynold's equation of Pressure Distribution which contains a function of this angle — for any definite position on the film pressure curve, as shown in the third equation of Figure 7.

The quantity of oil pumped by the journal varies, depending on the Sommerfeld number and in the Boyd charts is given as a variable, Q/RCNL. These calculations are based on 'no grooving.' Some authorities claim a circumferential groove will allow as much as four times the volume pumped compared to no grooving. However, its effect on the load per unit area must be considered before such a change is attempted.

As for what bearing clearance should be given, it is important to realize the effects of clearance. Figure 8 shows a typical set of curves plotted for one of our bearings. With increasing clearance, minimum film thickness has a maximum at a specific clearance; friction coefficient has a minimum point, flow has a peak point, etc. These curves were made at constant viscosity, speed and load. Only clearance was varied. Note the contrast in friction for the same ZN/P. Not shown, but also true, are:

1. Heat dissipation increases with clearance.
2. Load capacity depends on clearance.

If load capacity is limited by temperature, then increasing the clearance will increase the rate of heat dissipation. If load capacity is limited by film thickness, then a decrease in clearance will increase load capacity.

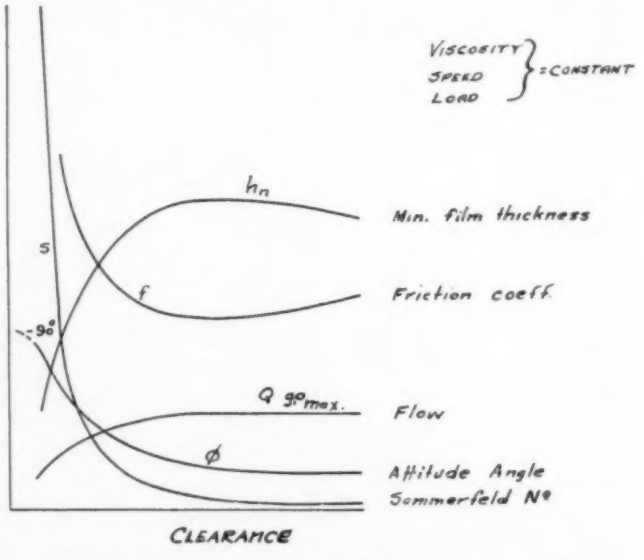

Figure 8 — The bearing clearance is one of the most important factors in bearing design.

Reference has been made a number of times to the Boyd-Raimondi curves. These valuable charts were published as part of a paper, "Applying Bearing Theory to the Analysis and Design at Journal Bearings — Parts I and II," by John Boyd and Albert A. Raimondi, Journal of Applied Mechanics, September 1951. The

original paper permitted studies of all bearing arcs and h_n/C ratios.

Having noted the influence of clearance on the load carrying film shape, along with all the other factors, we decided to follow through on a bearing, analyzing its characteristics from the standpoint of the Sommerfeld variable. We also wished to determine the applicability of the Boyd-Raimondi charts at the same time.

Our example is a back-up roll bearing for a cold strip mill. Admittedly, the authors developed the charts from the known theory principally for their own use on small bearings, but we thought if they should happen to apply to this type bearing, they would certainly be useful for smaller bearings subjected to less severe conditions.

The bearing we shall use in our illustration is one located on the bottom roll of a 56-in. cold mill whose delivery speed for purposes of this example was set at 3000 fpm, corresponding to 212 rpm for the roll. The latter's dimensions were accurately measured and found to be 32.992 in. for the roll neck diameter, while the bearing length was 28.500 in. The imposed load on the bearing varies depending on the type of rolling the mill is subjected to. For this particular installation, a limiting design load of 3,200,000 lb per screw had been established — this also representing the maximum load ever to be expected on the bearing. Any load under 3,200,000 lb would result in much better operating conditions for the bearing than we are imposing in this problem. But, for the sake of illustration we will hold to the 3,200,000-lb figure.

A detailed description of this type bearing was published in the AISE Recommended Bearing Practice and will not be repeated here. Suffice to say, oil enters the bearing at its very bottom, and then after dividing to either side, it passes through a labyrinth, entering the bearing just ahead of the pressure area. Leaving the load zone, it flows around the upper two-thirds of the neck, while at the same time becomes mixed with oil that had not actually been carried through the load zone. Thereupon, the oil leaves the bearing at the top before it enters the drain lines.

The diametrical clearance was approximately 0.035 in. or nearly 0.001 in. per in. of diameter. On the other hand, the radial clearance (the difference between bearing and journal radii) is actually very small since the pressure zone is scraped so that in effect the bearing approaches the fitted bearing class. Nevertheless, upon measurement, the radial clearances of several bearings were found to range between 0.004 in. to as high as 0.012 in. Readings were of course taken at room temperature and in an unloaded state and their accuracy depended on the method as well as the skill of the machinist. However, repeated measurements were made and results were consistent although conceivably off by several thousandths.

References to room temperature and unloaded condition are considered important points inasmuch as the radial clearance is expected to be diminished somewhat under load and at higher temperatures. Presently, we shall see just what that clearance must be in order for the bearings to be theoretically capable of working under the imposed conditions.

The bearing under study was found to have been relieved by scraping on either side of the oil entry holes for an estimated six in.

In effect, the bearing arc was reduced to an 80 degree included angle, which theoretically — everything else being equal — had the following effects:

1. Increased load per unit area.
2. Decreased the friction.
3. Decreased the horsepower due to friction.
4. Decreased the angle of closest approach.
5. Decreased the minimum film thickness.
6. Brought the line of maximum load close to the center line.
7. Reduced the amount of oil the bearing could pump.
8. Affected temperature rise — either increasing it or reducing it, depending on the Sommerfeld bearing characteristic number applying.

Since this bearing is in a cold mill, it is recognized that the true imposed load line is not necessarily vertical. The actual load line would be the resultant of the tension force and the vertical reducing force acting through the bearings towards the screws. Whereas, tension and reducing force vary from stand to stand, the line of action will also vary from stand to stand. The Boyd-Raimondi charts are for vertical loading for which reason a solution was made, assuming a vertical load "W." Since the bearing example is from a stand with little tension and also since it is believed little of the tension force is transmitted from the work roll anyway, the assumption of vertical loading is reasonable. In any case, the curves could still apply for non-vertical loading as long as the axis is shifted to the new line of action.

Another point of interest is the fact the shaft acting as a pump will only deliver a fraction of the oil that can be forced through the bearing. In addition, there is a theoretical amount delivered, were there no end leakage, and another and more accurate quantity when end leakage is taken into account.

The effect of surface finish, both neck and bearing does not enter the calculations; it being assumed that the peak to valley distances in the surface of either is far too small in comparison with the minimum film thickness. Surface smoothness or roughness has a great effect at low speeds or when the roll is starting from rest. Since wear is generally understood to occur principally at such times, any excessively rough surface will serve to accelerate the wear. Our journal has a surface polished to a finish between B and C of the AISE Surface Finish Standard (RMS of 8 to 16 or a peak to valley distance of 28 to 56 micro-inches). On the other hand, the babbitt bearing is subjected to the controversial practice of "flowering" its surface. Very slight, oval shape marks are scraped on the bearing surface to a depth of about ¼ of a thousandth or less. The entire surface is covered in this way, the old timers being convinced such a practice is necessary to provide a chain of oil reservoirs so that it would be impossible to ever be without oil. Despite the apparent disregard for the principles of hydrodynamic lubrication, it is a fact that the practice is successful. Perhaps, when starting from rest, these tiny craters do serve a real purpose for otherwise the entire neck would be in metallic contact with the bearing from one end of the arc to the other.

The oil used in our problem is presently a 1550 SSU oil @ 100 F — 96 Viscosity Index, a high grade solvent

refined straight mineral oil. It is desirable to know just what goes on within the bearing and to determine if possible what conditions must be met to provide the lowest temperature rise.

To check our work, thermocouples were installed giving the following results at these locations:

1. Temperature of the oil fed into the bearing — 100 F.
2. Temperature of the oil actually entering the load zone — 168 F.
3. Temperature of the babbitt at two points:
   a. 15 degrees from the centerline towards the inlet — 175 F.
   b. 15 degrees from the centerline towards the outlet — 200 F.
4. Temperature of the oil leaving the bearing at the drain line — about 12 in. from the chuck — 150 F.

Also taken were flows and oil line pressures at various speeds. Actual oil flows were between 4-5 gpm at 3000 fpm or 212 rpm.

The first attempt to apply the charts resulted in disturbing results. Assuming an average oil temperature of 175 F, a radial clearance of 0.004 in., the Sommerfeld number was calculated to be 6.16. Applying each chart and correcting for end leakage, we obtained answers such as these:

Minimum film thickness — 0.00098 in.
Angle of maximum film pressure — 3 degrees-15 min
Coefficient of friction — 0.000384
Equivalent friction horsepower — 66.6
Oil flow pumped through the load zone — 2.80 gpm (including 1.20 gpm end leakage)
Temperature rise — 306 F (obviously does not correspond with assumed film temperature of 175 F)

The latter figure seemed quite unreasonable but there were several points to remember. First, it only applied to the oil pumped through the load zone; secondly, our thermocouple readings were in the babbitt and not in the actual oil film whose temperature could be considerably higher; thirdly, the assumed load was very likely much higher than actual and, finally, there was the unaccounted for loss of heat to materials and surrounding air. As it turned out, the assumed film temperature was obviously too low inasmuch as it did not tie in with the theoretical temperature rise of 306 F. If the theory was anyway approximately correct, the film temperature should be about 341 F.

Using the viscosity at 341 F and a clearance of 0.004 in. gave results that were more fantastic. Sommerfeld number became 0.660 corresponding to a temperature rise of 920 F.

By trial and error, many other film temperatures were tried out but with a clearance fixed at 0.004 in., none could be reconciled with the temperature rises obtained. This implied either the technique was completely inapplicable or else the bearing conditions were impossible for hydro-dynamic lubrication.

A good way to check our theoretical results was to equate the heat generated in the oil film to the heat removed by the entire body of oil leaving the bearing. We know how much oil actually flows through the bearing, and we know what its actual temperature rise is. By setting up an equation as indicated, it will be possible to calculate how much oil must theoretically pass through the bearing to take away the heat generated in the film. Heat loss to materials can be disregarded. Though some loss does go into the journal and bearing, it is conventional in circulating system calculations to assume all the heat goes out with the oil. Of course, this is not strictly true — but after steady state is reached, it becomes a reasonable assumption.

By doing this, we determined that 2.80 gal calculated to be pumped through the load zone with a temperature rise of 306 F would require a total of 14.3 gpm through the entire bearing. In this way the overall oil temperature rise would be held to about 50 F which corresponds to the actual case for the total of 4 gpm metered through the bearing. This discrepancy, between actual (4 gpm) and theoretical (14.3 gpm), had to be resolved somehow. Realizing the bearing actually worked, we had to try to learn why this apparent discrepancy existed. Discounting the possibility of errors in measurement, it seemed that something must have occurred under load that was not suspected. There was evidence of less heat generated in the film than the large quantity of oil flowing through the 0.004 in. clearance would have generated. It was concluded less oil must be in the film resulting in lower total heat generation. Only a reduced film thickness could have been responsible and that might have occurred in two ways. Expansion in the materials due to temperature rise might reduce it somewhat. It is much more likely that at these very high loads, the bearing material deflects and conforms somewhat to the arc of the journal surface. When this occurs, the radial clearance becomes smaller, the arc of contact increases and the bearing approaches the fitted bearing class. However, note it never reaches it, for if it should, an entirely different theory would have to apply and such does not seem to be the case here.

Proceeding from this new point of view, a Sommerfeld number was selected for the lowest combination of temperature rise and flow. This could be done by inspection because the "S" vs temp rise curve is quite flat over a wide range of S. An S number of 5 was selected and subsequently found to be satisfactory.

After determining the rise to be 328 F (allowing for no side leakage), it was found the oil viscosity would be (0.67×10^{-6} reyns) at an estimated average film temperature of 332 F. This time, however, radial clearance would have to be 0.0015 in. and the total oil pumped through under the neck would be only 0.648 gpm. In other words, only approximately 16 per cent of the oil actually going through the bearing supported the load. The remainder served as coolant only. The maximum film pressure was 11,286 psi and was located 2 degrees-30 minutes off the center line.

Allowing for end leakage, the h_n/C ratio changes, affecting all of the parameters. Lower temperature results in a slightly more viscous oil supporting the load (0.91×10^{-6} reyns) with approximately 1.125 gpm flowing through the load zone. Of this, 46 per cent will be lost at the ends. The film pressure and angle of action would be nearly the same as before. The total oil (including the portion used for cooling) amounted to 5.73 gpm — much closer to the measured quantity, 4-5 gpm, then was obtained by our original assumption of 0.004 in. clearance.

The charts provide more data than given in this paper and what mathematics there is, is not too difficult to follow. Because of the complexity of the theory,

however, the authors found it necessary to make use of provisional Sommerfeld numbers in applying correction factors. This works no hardship if one follows closely the instructions supplied in the paper.

In conclusion, we hope to have stimulated interest in the Sommerfeld number as a workable criterion. ZN/P was tried on this problem using a ratio of 20 as prescribed by some authors. It was found a viscosity of 46.6×10^{-6} reyns would be necessary. Other authors have suggested a ratio of 5, giving a viscosity of 11.6×10^{-6} reyns. It is difficult to be sure of either as a satisfactory criterion. We do not believe it is possible without a knowledge of clearance and its effects to arrive at a solution that is dependable.

To summarize briefly, we have learned the following about one type of cold mill backup bearing from use of the Boyd charts:

1. At very high unit loads the bearing will support the load in the hydrodynamic range only at very low radial clearances.
2. For very high loads, changing oil viscosity does not affect the temperature rise nor the load carrying capacity as much as does a change in clearance.
3. At high loads, such as 3000 psi, temperature rises seem to be in the order of 300 F. This is completely plausible in view of the small amount of oil theoretically considered to be carrying the load.
4. Increasing radial clearances (lower S numbers) may produce temperature rises that approach the flash point of the oil and the oxidation temperature of some bearing materials. This theory may be the explanation for the presence of tin oxide on some high speed stand bearings.
5. A very light oil (0.91×10^{-6} reyns at 300 F) can carry these loads at the proper radial clearances.
6. Beyond a certain lower limit it is theoretically impossible to reduce the temperature rise in the oil other than by reducing the load or by finding means to take the heat away.

You will see therefore the Boyd charts have given us much food for thought. We believe, in concentrating plain bearing data, they have accomplished a great deal towards simplifying solutions of such problems.

From the foregoing analysis it appears that they could form a basis for further study of steel mill bearings. It is our opinion, however, that more accurate data is desirable, particularly as to the effects of heat losses and viscosity increase due to high pressures. Up until now, even including the charts, the process of designing plain bearings is not the easiest of problems, so that any further addition should be in line with the work already begun by Boyd and Raimondi.

However, until something better comes along, serious thought should be given to the application of these Sommerfeld charts in steel mill bearing design. Possibly, after sufficient data have been assembled, consideration might be given towards incorporating more of them in the AISE Recommended Plain Bearing Practice.

APPENDIX

EXAMPLE: Sparrows Point 56-in. Cold Mill Back-up Bearing — Fifth Stand

Given the following information, determine: 1. correct radial clearance for minimum oil film temperature rise, 2. other bearing properties per J. Boyd's Sommerfeld charts, and 3, theoretical oil requirements.

Oil Specifications

A.P.I. = 27.0
Vis @ 100 F = 1550/1650
Vis @ 210 F = 114
V I = 96

Bearing Journal Data

W—Load =

6,400,000 lb separating force or	3,200,000 lb per bearing
45,000 lb roll weight or	23,500 lb per bearing
Total	3,223,500 lb per bearing

$$P = \frac{W}{2RL} = 3420 \text{ psi}$$

$R_{(journal)} = 16.492$ in.
$\beta = 80$ degrees (bearing arc) scraped down from original 120 degrees
B = 23.05 in.
L = 28.50 in.
N = 212 rpm (equivalent to 3000 fpm)

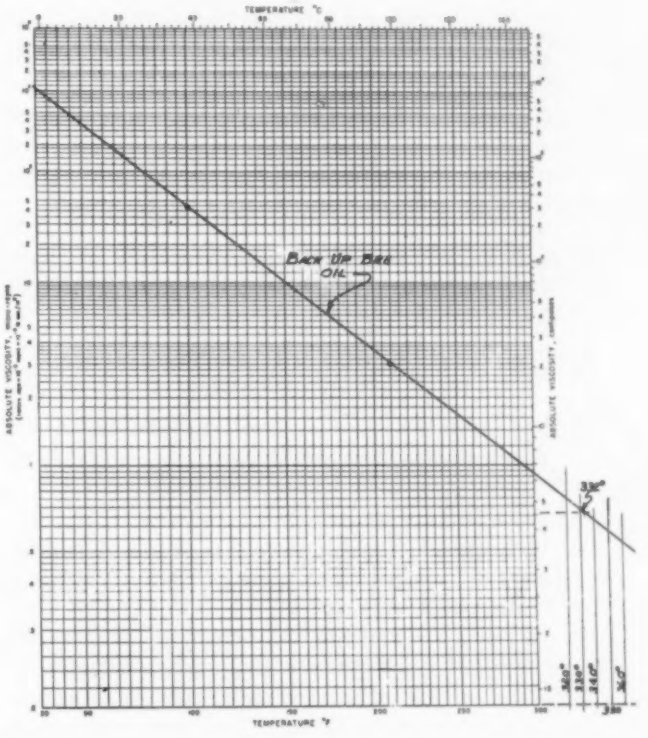

Figure 9 — Chart shows variation of viscosity with temperature.

Observed Oil Temperatures

Oil supply to bearing	= 100 F
Oil temperature actually entering bearing zone	= 168 F
Oil temperature at discharge	= 150 F

In this problem it is understood that oil is fed to the bearing under pressure at 100 F, passes through a labyrinth under the babbitt liner prior to entry under and around the roll neck itself. Upon doing so, some of it is carried under the neck to carry the load while the remainder goes around the top towards the discharge. The load carrying film of oil under the neck generates

heat and leaves the load zone at a much higher temperature, but mixes with the cooler volume of oil already passing around the top portion of the journal on the way to the discharge ports. Thus, of the oil passing through the bearing, only a portion of it actually carries the load, generating heat at the same time. The final outlet temperature of 150 F used in this problem represents an overall 50 F rise in the total bulk of oil passing through the bearing, whereas the temperature rise of that portion of this total oil providing the hydrodynamic film can be considerably higher.

Solution

Step No. 1—Plot viscosity-temperature curve on Boyd chart No. 1. For temperatures above 320 F, extrapolate. (See Figure 9.)
Make conversions to units employed by Boyd.

Step No. 2—Select an S number from chart No. 7 in a range of low temperature rise variable to 80 degree arc bearing (between S = 5 to S = 12). Select S = 5 since it provides a minimum temperature rise at a maximum clearance—everything else being constant. This is desirable since flow is higher and friction should be lower.

Step No. 3—Taking S = 5, pick off chart No. 7 the temperature rise variable and solve for Δt

$$\frac{10\ \Delta t}{P} = 1.3$$

$$\Delta t = 1.3\ \frac{(3420)}{10} = 444\ F$$

Step No. 4—*Make corrections in* Δt so that it applies to our oil and not the one Boyd used in making up chart No. 7 as follows:

$$\text{Correction Factor} = \frac{0.332}{\text{specific gravity} \times \text{specific heat}}$$

(See curve Figure 10).

a. Assume mean temperature of the film = initial temperature plus ½ the temperature rise.
b. Initial temperature = 168 F (observed).
c. Plot specific gravity vs temperature, specific heat vs temperature, and correction factor vs temperature. (Figure 10).
d. Assume a corrected temperature rise Δt_c (less than 444 F). Estimate mean temperature ("a" above). Pick off correction factor at this temperature and multiply the uncorrected Δt, (444 F). (Figure 10).
e. If this new Δt (corrected) equals the Δt assumed in "d" then the assumed Δt is correct and the accompanying mean temperature is the average oil film temperature to use in the problem hereafter.
f. In this case an assumed Δt of 328 F gives a mean temperature of 332 F. The correction factor for this oil at 332 F was found to be 0.734. Temperature rise = 444 × 0.734 = 327 F (agrees closely with assumed Δt = 328 F).

Step No. 5—*Find viscosity* of oil at this mean temperature from chart 1:

$$\mu = 0.67 \times 10^{-6} \text{ reyns}$$

Step No. 6—Solve for *radial clearance* corresponding to the conditions of the problem:

$$S = \frac{(R)^2}{(C)}\ \frac{\mu N}{P}$$

$$C^2 = \frac{(R)^2}{S} \times \frac{\mu N}{P} = \frac{(16.492)^2\ (0.67 \times 10^{-6})\ (212)}{(5)\ (3420)}$$

$$C^2 = 2.26 \times 10^{-6}$$
$$C = 0.0015 \text{ in.}$$

Step No. 7—Solve for minimum film thickness, h_n:

Pick off $\frac{h_n}{C} = 0.275$ from chart 4 at S = 5 and β = 80 degrees

$$h_n = (0.275)\ (0.0015) = 0.00041 \text{ in.}$$

Step No. 8—Solve for coefficient of friction—Chart 1

$$\frac{R}{C} f = 1.15$$

$$f = \frac{1.15\ (0.0015)}{16.492} = 0.0001045$$

Step No. 9—Solve for friction horsepower—Chart 2

$$\frac{10^5 H}{WNC} = 1.82$$

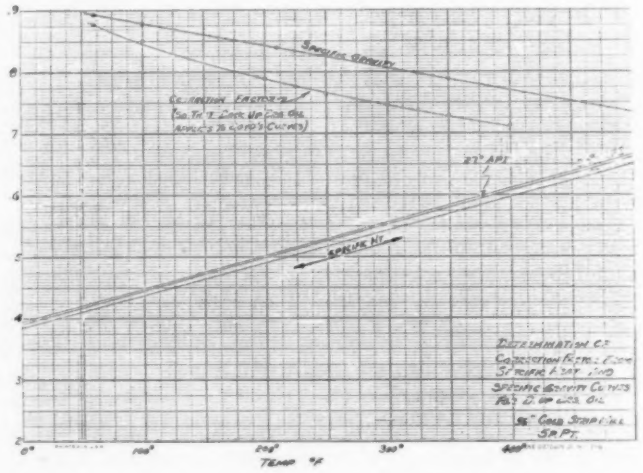

Figure 10 — Chart gives correction factors to adapt Boyd chart to the oil used in the sample problem.

$$H = \frac{1.82\ (3.22 \times 10^6)\ (1.5 \times 10^{-3})\ (212)}{(10^5)} = 18.6 \text{ hp}$$

Step No. 10—Solve for ϕ, position of minimum film thickness—Chart 3

ϕ = 22 degrees-30 min

Step No. 11—Solve for θ (P_{max}) position of maximum P—Chart 5

$\theta_{P_{max}}$ = 2 degrees-30 min from center line

Step No. 12—Solve for position of maximum negative pressure

$\theta_{P_{min}}$—Chart 5

Answer: $\theta_{P_{min}}$: (outside bearing area) OK

Solve for point of transition from positive pressure to negative pressure θ_{ps}

Answer: θ_{ps}—outside bearing area—OK

Step No. 13—Solve for maximum film pressure—Chart 11:

$$\frac{P_{max}}{P}=3.3 \qquad \left(\frac{h_n}{C}\right)=0.275$$

$$(B/L)=0.808$$

$$P_{max}=3.3\ (3420)$$
$$=11{,}286 \text{ psi}$$

Step No. 14—Solve for (gpm) flow through film—Chart 6

$$\frac{Q}{RCNL}=1.0$$

$$Q=(1.0)\ (16.492)\ (1.5\times10^{-3})\ (212)\ (28.5)$$
$$=149 \text{ cu in./min}$$
$$=0.648 \text{ gpm}$$

Step No. 15—Solve for total volume of oil required by bearing to limit overall temperature rise to 50 F assuming all heat is taken away by the oil:
Heat generated by film = heat taken away by bulk oil

film	*bulk*
Δt film = 328 F	Δt = 50 F
average specific heat = 0.570	average specific heat = 0.46
Q_f (gpm) = 0.648	Q_t (gpm) = ?

$$(328)\ (0.570)\ (0.648)=Q_t\ (50)\ (0.46)$$

Q_t = 5.26 gpm required (no side leakage)

Step No. 16—Interpretation
Ignoring effects of end leakage, possible variation of viscosity due to extreme pressures and heat losses to surroundings, the amount of oil required to take the heat generated by the film away would have to be 5.26 gpm under the conditions of the problem. The temperature rise in this bulk oil is limited to 50 F under the conditions imposed.

Step No. 17—*Applying Correction Factors for Side Leakage*—
Since Steps No. 1 through No. 16 apply to a bearing of infinite length (L/D = ∞), it is necessary to see what effect the escape of oil through its ends will have on the results. Now in our problem, L/D = 0.865 and arc/length = 0.808.
Boyd's curves are all based on L/D = ∞. In order to have them apply to a bearing of a fixed L/D, correction factors have been worked out and plotted for varying h_n/C and B/L ratios that, if applied correctly to the L/D = ∞ curves, will give the same result as could be obtained if there were curves available at a stated L/D. To do this, it is necessary to find a provisional Sommerfeld number which, when applied to the charts, will furnish figures to which the correction factors are to be applied. Though seemingly a roundabout way, the technique is not too difficult to follow in Boyd's examples.

1. Since C is now given (C = 0.0015 in.), our problem is similar to Case II (cf Boyd).
2. Find new h_n/C and mean film temperature applying. Assume a mean film temperature. To illustrate use t_m = 332 F (same as was found to be correct for L/D = ∞ for this bearing). t_m = 332 F should prove to be incorrect in this case.

a. At t_m = 332 F, $\mu = 0.67\times10^{-6}$ reyns; S = 5

b. Assume h_n/C = 0.3, K_w = 0.64—Chart 9 } provisional S_o = 5 (0.64) = 3.20

At S_o = 3.20
h_n/C = 0.21—Chart 4
= does not check with h_n/C = 0.3

Assume h_n/C = 0.245, K_w = 0.655 } S_o = 5(0.655) = 3.27; h_n/C = 0.215—still off—Say h_n/C = 0.23

Assume h_n/C = 0.23, K_w = 0.66 } S_o = 3.30; h_n/C = 0.218

Assume h_n/C = 0.22, K_w = 0.662 } S_o = 5(0.662) = 3.31—OK; h_n/C = 0.219—OK (close to assumed h_n/C = 0.22)

c. At h_n/C = 0.22 S_o = 3.30 K_w = 0.662 K_t = 0.56

$$\left(\frac{10\Delta t}{P}\right)=1.38;\ \Delta t=(1.38)\ (342)\left(\frac{0.56}{0.662}\right)$$
$$=399 \text{ F (For Boyd's oil)}$$

Uncorrected film temperature: $t_m = 168 + \frac{399}{2}$

= 368 F (correction factor @ 368 F = 0.724)
Therefore Δt_c = (399) (0.724) = 288 F

Correct film temperature = $168 + \frac{288}{2}$ = 312 F

Does not agree with t_m assumed of 332 F. (Assumption of 332 F was incorrect as expected.)

Therefore, the foregoing must be repeated until the assumed h_n/C and t_m together agree with the ones picked off or calculated at the provisional Sommerfeld number. It is a technique of trial and error, but a very close approximation can be achieved by this method. Now assume t_m = 300 F, then viscosity would be 0.91×10^{-6} and S = 6.78.

d. Assume h_n/C = 0.25, K_w = 0.658 } S_o = 6.78 (0.658) = 4.45; h_n/C = 0.26

Assume h_n/C = 0.255, K_w = 0.657 } S_o = 6.78 (0.657) = 4.44; h_n/C = 0.256 OK

At S_o = 4.44 h_n/C = 0.255 K_t = 0.57 K_w = 0.657

$$\frac{10\Delta t}{P_o}=1.3;\ \Delta t=(1.3)\ (342)\left(\frac{0.57}{0.657}\right)=386 \text{ F}$$

Uncorrected $t_m = 168 + \frac{386}{2}$ = 361 F;

(@361 F correction factor = 0.725)
corrected Δt = 386 (0.725) = 279 F

corrected mean film temperature = $168 \text{ F} + \frac{279}{2}$ = 307 F

307 F is close to assumed 300 F

e. Therefore S (actual) = 6.78
S_o = 4.44 (provisional)
h_n/C = 0.255
Δt = 279 F
t_m (film) = 300 F
μ (visc film) = 0.91×10^{-6}

3. At calculated h_n/C and B/L find all the correction factors from the charts

K_t = 0.57 K_P = 0.94
K_w = 0.657 K_Q = 1.85

4. Position of minimum film thickness $S_A = S_o = 4.44$
(Use no correction factor—cf Boyd)
$\phi = 22$ degrees-0 min

5. Coefficient of friction: Use S_o and correction factors K_F and K_w

$$\left(\frac{R}{C}f\right)_o = 1.1 \qquad f = 1.1\left(\frac{0.0015}{16.492}\right) \qquad \left(\frac{K_F}{K_w}\right)$$

$$= 0.000143$$

6. Horsepower loss: Use S_o and correction factors K_F and K_W

$$\left(\frac{10^5\,H}{WNC}\right)_o = 1.75;\ H = 1.75$$

$$\left(\frac{3.22 \times 10^{-6} \times 212 \times 1.5 \times 10^{-3}}{10^5}\right) \quad \left(\frac{0.94}{0.657}\right)$$

$$= 25.4 \text{ hp}$$

7. *Flow* through film: Use S_o and correction factor K_Q

$$\left(\frac{Q}{RCNL}\right)_o = 0.94;\ Q = 0.94\ (16.492)\ (0.0015)$$

$$(212)\ (28.5)\left(\frac{1}{231}\right) K_Q = 1.125 \text{ gpm}$$

Per cent lost to side leakage—
$Q_s/Q = 0.46$ or 46 per cent
$Q_s = (0.46)\ (1.125) = 0.518$ gpm lost
$1.125 - 0.518 = 0.607$ gpm through bearing

8. Total flow through bearing including cooling oil:

Δt film $= 279$ F $\qquad \Delta t_{Q_s} = \dfrac{279 \text{ F}}{2} = 139$ F

$t_m = 168$ F $+ 139$ F $= 307$ F $\qquad t_{Q_s} = 168 + \dfrac{139}{2} = 237$ F

specific heat $= 0.558$ $\qquad$ specific heat $= 0.520$

$\Delta t_{bulk} = 50$ F
$t_m = 125$ F
specific heat $= 0.46$

$$Q_t\ (50)\ (0.46) = (0.607)\ (279)\ (0.558) + (0.518)\ (139)\ (0.52)$$

$$23Q_t = 94.5 + 37.4 = 131.9$$

$$Q_t = 5.73 \text{ gpm}$$

9. Position of maximum and minimum pressures
$\theta_{P_{max}} = 3$ degrees-0 min
$\theta_{P_{min}} =$ outside arc
$\theta_{ps} =$ outside arc

10. Maximum pressure
$P_{max}/P = 3.4 \quad P_{max} = 3.4\ (3.42 \times 10^3) = 11{,}600$ psi

SUMMARY OF RESULTS

	No side leakage (L/D = ∞)	Allowing for side leakage (L/D = 0.865)
Sommerfeld	5.0	6.78
Film temperature rise, F	328	279
Mean film temperature, F	332	300
Oil viscosity, reyns	0.67 x 10^6	0.91 x 10^6
Radial clearance, in.	0.0015	0.0015
Ratio $\left(\frac{\text{Minimum film}}{\text{Radial clearance}}\right)$	0.275	0.255
Minimum film thickness, in.	0.00041	0.000382
Coefficient of friction	0.0001045	0.000143
Friction horsepower	18.6	25.4
Position of minimum film, degrees-min	22-30	22-0
Position of maximum pressure, degrees-min	2-30	3-0
Position of negative pressure	Outside bearing arc	Outside bearing arc
Position of atmospheric pressure	Outside bearing arc	Outside bearing arc
Maximum film pressure, psi	11,286	11,600
Oil flow through film, gpm	0.648	0.607
Oil loss by leakage, gpm	.....	0.518
Total oil through load zone (film and side leakage), gpm	0.648	1.125
Bulk oil flow demanded by bearing (including cooling oil), gpm	5.26	5.73

These results are shown in Figure 11.

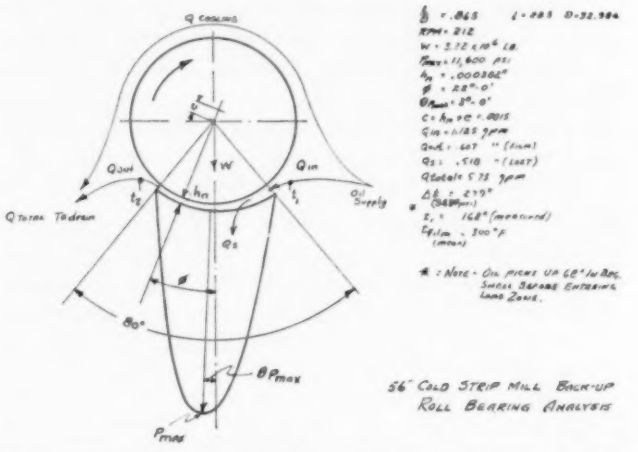

Figure 11 — Sketch summarizes solution of mill bearing.

SUMMARY

The difference between allowing for side leakage and not allowing for it does not seem to be too great in this particular bearing. Actually, the amount of oil required to carry the load is nearly double; but the total oil flowing through the bearing increases only about 10 per cent.

Thermocouples placed in the load zone of this bearing have read 200 F even though the overall temperature rise for the bulk oil was 50 F over the inlet oil of 100 F. Recognizing the fact there can be and may actually well be a high temperature gradient between the oil film temperature and the babbitt temperature, the theoretical temperature rise of 279 F seems plausible.

Another point of interest is the relatively small differential between the meter readings of 4-5 gpm and the theoretical 5.73 gpm. The difference may well

represent the amount of heat taken away by the adjoining metals which we assumed was removed by the oil.

Of the greatest interest, however, is the calculated clearance of 0.0015 in. Following the theory as set forth by Boyd, the best condition in which this bearing is to work at these high loads can only be in the range of such small clearances. (Lower loads permit a much larger clearance).

A change in Sommerfeld number keeping P,R,N. constant will have the following effects on this bearing:

(between 5 down to 0.5)—
Temperature rise increases sharply.
Clearance increases up to 0.0026 in.
Oil flow reduces sharply.

(between 5 and 12)—
Temperature rise lowest and a constant.
Clearance reduces (0.0015 to 0.0009 in.)
Oil flow maximum and constant.

(between 12 and 30)—
Temperature rise increases.
Clearance decreases (0.0009 to 0.00055 in.)
Oil flow diminishes.

Apparently a clearance of approximately 0.0015 in. must exist under the conditions imposed for this bearing to work. It is believed temperature expansion effects and babbitt distortion under load combine to produce such a clearance under load.

Pressure-viscosity effects at high loads may also have some bearing on the problem, too. In a word, the correct clearance to bore must consider all these factors. What this example does is to point up the fact that under the conditions imposed, a radial clearance of approximately 0.0015 in. must exist for the bearing to be able to support the load with the oil in the hydrodynamic region.

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J. Boyd and A. A. Raimondi: Mr. Cichelli has ably treated a rather difficult subject and has called attention to the importance of clearance and the Sommerfeld number on bearing operation and design. The writers were extremely interested in his attempt to apply their charts to a typical steel mill bearing problem. Mention should be made that the charts to which Mr. Cichelli refers were not originally intended for designing steel mill bearings as they are purely theoretical and based on certain simplified assumptions. The closer a problem fits these assumptions, the more reliable will be the results obtained from the charts.

Rolling mill journal bearings are a class of extremely heavily loaded bearings; because of this many complications are introduced in their theoretical analysis if all the possible factors influencing their operation are considered. For example, the variation of lubricant viscosity and density with pressure and temperature, bearing distortion and shaft deflection are a few factors which exist and influence the performance of these bearings. These and other influences have been neglected in the charts in order that simplified solutions to problems may be obtained.

The results obtained from a simplified theoretical analysis should always be tempered in accordance with the degree to which the neglected influences exist in the problem under consideration. Because this is difficult to do in a practical case, it is felt that the value of the charts lies not so much in giving absolute answers, but in allowing one to evaluate and compare different designs and to investigate the effects of changing certain variables. As an example of the use of the charts, the effect of load, viscosity, inlet oil temperature and heat conduction on a typical steel mill bearing will be illustrated in the following paragraphs. The calculator need not have an elaborate background in the theory of lubrication, but should possess only a few simple concepts which will be described as the need arises.

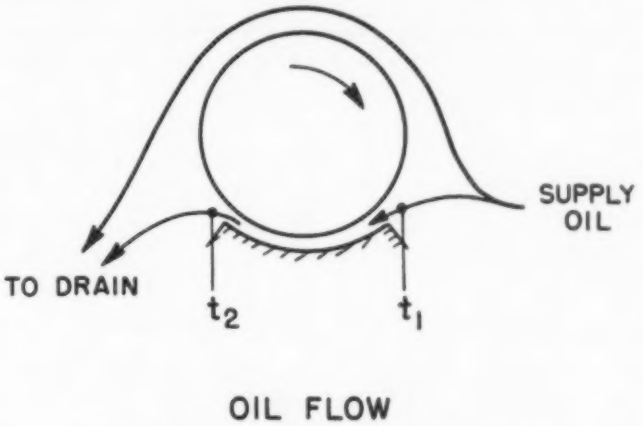


Figure 12 — Oil flow is given in this sketch.

The bearing selected for the purpose of illustration was the same one described by Mr. Cichelli having an active bearing arc of 80 degrees, a radius R = 16.5 in., an axial length L = 28.5 in. and an operating speed N = 212 rpm. Various radial clearances were chosen. In this discussion radial clearance and minimum film thickness are given in mils. One mil = 0.001 in. The following bearing characteristics were calculated:

a. *Power loss*—This is the power required by the shaft to overcome the viscous friction of the oil passing through the active bearing area (which

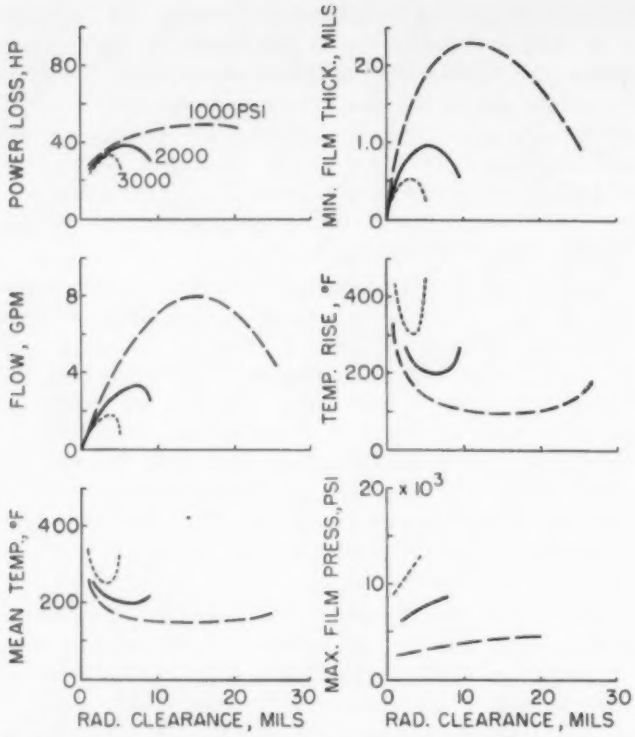


Figure 13 — Curves give effect of varying unit load, assuming inlet temperature of 100 F, and viscosity of 1500 SSU at 100 F.

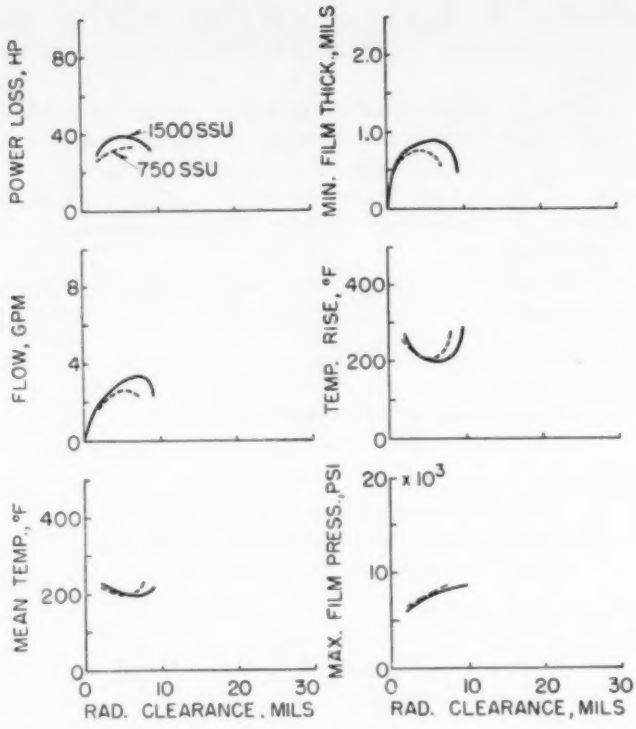


Figure 14 — Curves give effect of varying viscosity, assuming inlet temperature of 100 F, and unit load of 2000 psi.

consists of the surface bounded by the bearing arc (80 degrees) and the bearing length, L=28.5 in.).

b. *Minimum oil film thickness*—This is the thickness of the oil film at the closest point of approach of the shaft and the bearing.

c. *Oil flow*—Emphasis should be made that this quantity is the flow which passes across the active bearing area only. Regardless of the quantity of oil supplied by an external pump, only a certain amount will pass through the load area; the excess oil flows over the top of the shaft and out through the drain pipe and serves no useful purpose as far

Figure 15 — Curves give effect of varying inlet temperature, assuming viscosity of 1500 SSU at 100 F and unit load of 2000 psi.

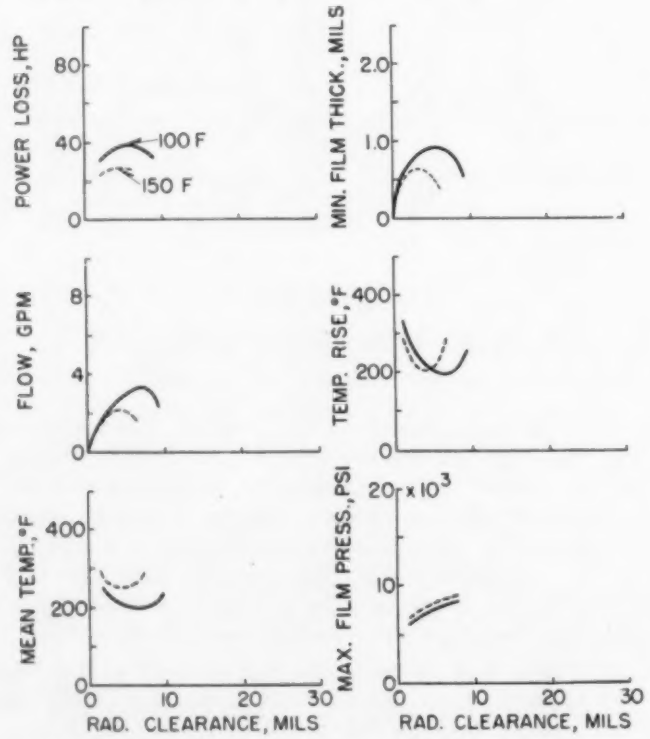
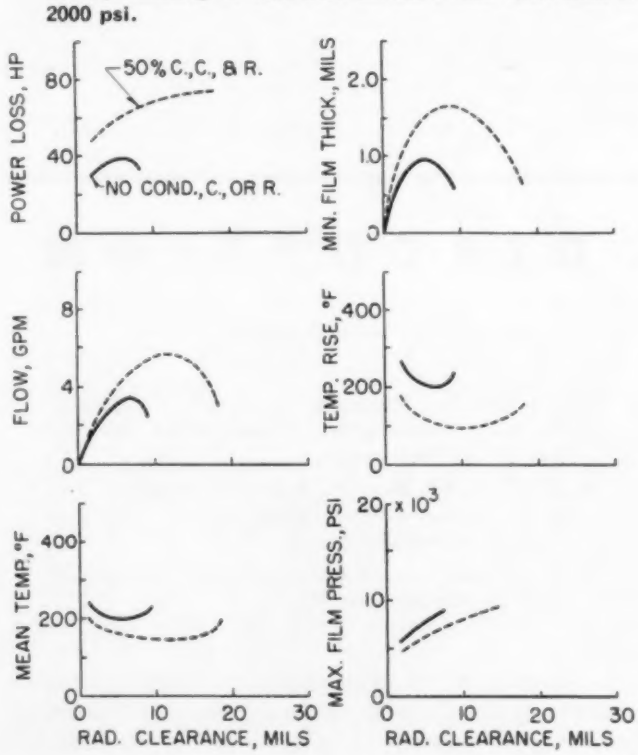


Figure 16 — Curves give effect of heat conduction, convection and radiation, assuming inlet temperature of 100 F, viscosity of 1500 SSU at 100 F and unit load of 2000 psi.



as load carrying capacity is concerned other than to act as a coolant. (See Figure 12).

d. *Temperature rise*—This is the temperature rise of the lubricant above the inlet oil temperature and is defined as:

$$\Delta t = t_2 - t_1$$

where:

t_1 = temperature of oil as it enters the leading edge of bearing arc.

t_2 = temperature of oil as it leaves the trailing edge of bearing arc.

e. *Mean temperature*—This is the average temperature of the oil in the active bearing area and is taken equal to the sum of the inlet temperature plus one-half the temperature rise, i.e.,

$$t_m = t_1 + \frac{\Delta t}{2}$$

f. *Maximum film pressure*—This is the maximum pressure developed within the oil film by the pumping action of the shaft.

The details associated with the method of calculating these quantities need not be given here at the present time. It is hoped to publish them elsewhere at a later date. The results of the calculations are given in Figures 13, 14, 15 and 16. Since Mr. Cichelli has stressed the importance and influence of clearance on bearing performance, this variable has been chosen as the abscissa for all the graphs. The results are rather interesting and will be discussed individually.

EFFECT OF LOAD

Figure 13 shows the effect of changing unit load. Since 2000 psi seemed to be an average value of the unit loading encountered in rolling mill bearings, the curve corresponding to this load is shown as a solid line in Figures 13, 14, 15 and 16, the solid line is also meant to imply the use of a 1500 SSU oil (at 100 F) and an inlet oil temperature of 100 F. With reference to Figure 13, one notes that increasing the load decreases the minimum film thickness. This is what one would naturally expect since the heavier load would tend to squeeze the lubricant out of the active bearing area. It can also be seen that for any given load, there is a value of radial clearance which yields an optimum minimum film thickness. The existence of such a clearance is to be expected, for it is obvious that if one continuously increases the clearance, the shaft will sink lower and lower in the lubricating film until contact occurs. On the other hand, if one keeps making the clearance smaller, it is equally evident that it will not be possible to build up a minimum film thickness whose absolute value is large since it cannot exceed the radial clearance. Since the bearings in this paper are limited to the centrally loaded class, this is true. Hence, some optimum value must exist between these two extreme conditions.

It is also interesting to observe that, contrary to expectations, increasing the load decreases the power loss. This is due to the fact that the mean temperature of the oil has increased considerably, lowering its viscosity and hence the power loss due to viscous friction. It seems that the decrease in power loss due to the decrease in viscosity is more than enough to counteract the increase in power loss that results from a decrease in minimum film thickness. The decrease in flow with increase in load is explained by the fact that the minimum film thickness is less, so that the shaft cannot pump as much oil through the smaller space. The large increase in maximum film pressure with increased load arises because increased fluid pressures must be generated within the film if the load is to be sustained by hydrodynamic action.

An important fact is indicated by all the curves in general, but in particular, by those of temperature rise and minimum film thickness. These curves show that the range of clearance for successful operation is drastically reduced when loads are increased. Moreover, they also show that the actual clearance values become smaller with increase in load. This is indicated in the minimum film thickness graph by the shift of the peaks of the curves to the left as the load is increased, and in the temperature rise graph by the shift of the minimum points of the curves to the left. One can conclude from this, that in spite of the large nominal clearances cited for these bearings, the effective operating clearance must be very small if these bearings are to perform satisfactorily without excessive temperature rise. The removal of heat from the oil film by means of conduction, convection or radiation alleviates this situation to some degree as can be seen by Figure 16.

EFFECT OF VISCOSITY

In order to investigate the effect of viscosity, calculations were made using an oil whose viscosity at 100 F was approximately one half that of the oil used in the preceding figure. Figure 14 indicates that a lighter oil seems to have no appreciable effect on temperature rise or mean temperature except to slightly decrease the range of clearance for successful operation. The minimum film thickness is reduced, however, because the viscosity of the oil is less at the same mean oil film temperature. The power loss is less for the same reason. The flow decreases because the minimum film thickness is reduced offering less space through which the oil can be pumped.

EFFECT OF INLET OIL TEMPERATURE

The effect of changing the inlet temperature of a 1500 SSU oil from 100 F to 150 F is shown in Figure 15. The results shown are the same in character as those given in Figure 14 when a less viscous oil was used. The explanation for the various curves would be identical with those given in the preceding paragraph.

EFFECT OF HEAT CONDUCTION, CONVECTION AND RADIATION

The preceding figures had the underlying assumption that all the power loss went into raising the oil film temperature and that none of it was dissipated by some cooling means, that is, by conduction, convection or radiation. In roll neck bearings, operating under heavy

loads and with high oil film temperatures, this assumption is questionable. Therefore, in order to discover what effect cooling would have, it was arbitrarily assumed that of all the power absorbed by the oil film, fifty per cent was dissipated by means of either conduction, convection or radiation. Whether or not fifty per cent is a reasonable figure does not prevent one from making a qualitative estimate of the effects of conduction, convection or radiation.

Figure 16 illustrates that greater power loss is to be expected when conduction, convection and radiation are taken into account. This may be explained by referring to the temperature rise and mean temperature curves which show the oil film temperature to be appreciably lowered. This is what one would naturally expect when some means of cooling the bearing exists. The viscosity is, therefore, increased and the bearing will require more power to operate. In addition, because of this increased viscosity, the bearing will operate with a greater minimum film thickness as indicated by the curves. Due to this increased film thickness, more oil can be pumped through the load area by the shaft.

The writers agree with Mr. Cichelli when he states that the design of plain bearings from available information is not a simple problem and that further simplification would be desirable. Although the charts are a step forward in making bearing analysis and design simpler, it is believed that they could be improved for use in designing steel mill bearings. The charts were originally intended to cover the wide range of bearing arcs and length-to-diameter ratios which exist in current practice. However, since rolling mill bearing arcs and proportions are relatively fixed it might be possible to make charts for their analysis and design which would already be corrected for side flow and thus reduce the labor involved in calculation.

A. E. Cichelli: There is little we can add to this new contribution by Messrs. Boyd and Raimondi except to thank them for their interest and their valued help. When we first consulted with them on this problem, we had given them an inlet temperature that was not quite accurate. The inlet temperature of 168 F used in our calculations was actually measured and was higher than the assumed temperature we had given the discussers. Nevertheless, in their analysis of the effect of changing inlet temperature, it is clear that the difference between 150 and 168 F is not too great.

Their comments and graphs contain extremely valuable data and should go a long way towards emphasizing the importance of clearance and towards throwing some light on a singularly difficult bearing application in the steel mill industry.

It is our hope that many others will study these data, criticize them, then submit their comments to us. We are all seeking as the ultimate goal, an improvement in bearing performance—by an improvement in its design. If this recent work of Boyd and Raimondi will help us toward that end, and I believe it will, then we should by all means make more use of it and thereby come one step closer to that goal's fulfillment.

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MAINTENANCE OF INDUSTRIAL ELECTRONIC EQUIPMENT

By WILLIAM FEW
Manager of the Electronics and Allied Products Div.
The Clark Controller Co.
Cleveland, Ohio

. . . . maintenance on electronic equipment has held back its use in steel plants . . . . the following provides some very valuable pointers which will help the maintenance man . . . .

▲ THE performance or service which industrial electronic equipment can provide is largely dependent on its proper maintenance. Breakdowns are costly not only in the cost of repairs, but more important, in valuable production time. Maintenance measures should include not only the prompt servicing of faults or breakdowns, but also preventive steps to insure continued maximum performance for long periods of time. In the following paragraphs, helpful procedures and hints will be outlined for the preventive maintenance and servicing of industrial electronic equipment.

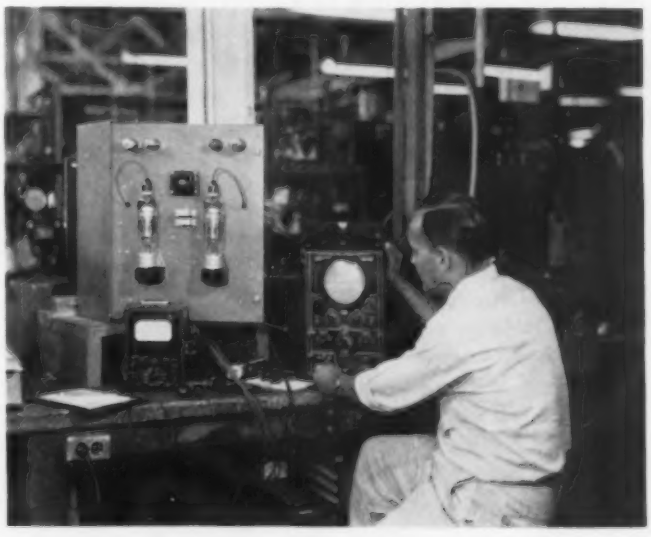
SAFETY

It is imperative that safety measures be taken before and during the time maintenance is being performed. Every precaution should be employed to prevent injury to personnel and equipment. Electronic equipment often operates at high voltages, necessitating extreme care. Before attempting any maintenance work on electronic equipment requiring personal contact with components, two safety precautions should be taken.

1. Remove all power from equipment when replacing parts.
2. Discharge capacitors.

Certain tests require that the equipment be energized. During these tests, special precautions must be taken by the maintenance man in order to avoid coming in

Figure 1 — Adjusting the cathode ray oscilloscope while servicing an electronic voltage regulator.



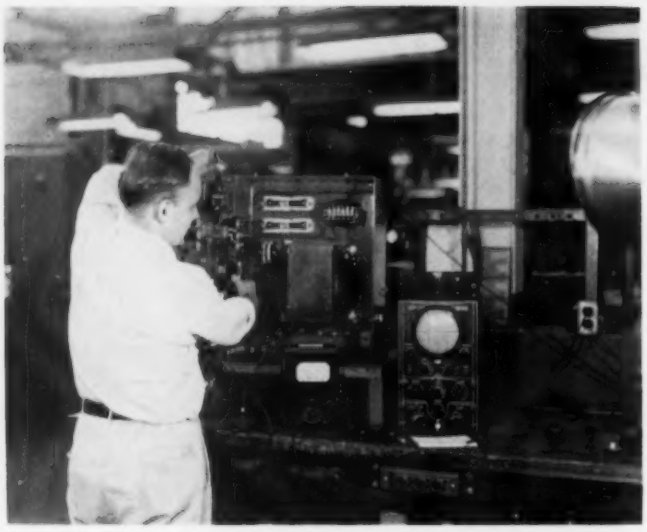


Figure 2 — An analyzer is as an aid to the servicing of industrial electronic equipment.

personal contact with live parts. The importance of safety cannot be over-emphasized.

MAINTENANCE RECORDS

Complete and accurate maintenance records must be kept. These records should include the following reference material:

1. Schematic diagrams.
2. Wiring diagrams with the components and wiring in their correct structural position.
3. Tables of symbols commonly used in electronic diagrams. Such a table is shown at the end of this discussion.
4. Resistor and condenser color code charts. A chart of this kind is shown at the end of this discussion.
5. Tube characteristics.

These records should also include design data to serve as a means of comparison when abnormal conditions arise. The data should include voltage and current measurements and sketches of wave forms, as indicated on a cathode-ray oscilloscope, for the various circuits in the equipment. Much of this data is available from information supplied by the equipment manufacturer, or it may be obtained by taking measurements when the equipment is functioning properly.

A complete written record of all work done and results of tests made during maintenance is important. This information may be helpful in locating faults and the service record of every component will help determine approximately when replacement will be needed.

INSTRUMENTS

Test instruments of a suitable nature are necessary to check the operation of electronic equipment. The number and type of tests that may be performed depends on the test equipment available to the maintenance man. Those most desirable are:

1. D-c multirange voltmeter with a resistance of at least 20,000 ohms per volt.
2. A-c multirange voltmeter.
3. Ohmmeter.
4. D-c multirange milliammeter.
5. Cathode-ray oscillograph.

Some of the instruments may be seen in use in Figure 1. A good analyzer or multimeter will serve for all measurements requiring the first four items listed above, except high impedance control grid circuit voltages and very low resistance measurements. High impedance circuits should be measured with a vacuum tube voltmeter, which will permit the measurement of voltages without disturbing the circuit.

The cathode-ray oscillograph is a very useful and sometimes very necessary instrument. It is required when observations of wave forms, such as the shifting of the grid voltage of thyratrons, and the determination of the instantaneous polarity of transformers, are needed. This instrument also has many more important uses. If one is available for use by the maintenance man, it is recommended that the instruction book accompanying the instrument be studied thoroughly for its applications.

PREVENTIVE MAINTENANCE

Periodic inspections serve as preventive steps to reduce major breakdowns. Careful inspections should include the observation of temperature conditions, cleanliness, thyratron and control tube operating appearance, and the condition of relays, contactors and other moving parts. Any meters within the unit should be observed for abnormal readings.

Temperature — Overheating may be indicated by discoloration, warping or blistering of the components or leakage of insulating compounds. Feeling components such as resistors, capacitors, and wiring, also serves to locate any overheating which may lead to an eventual breakdown.

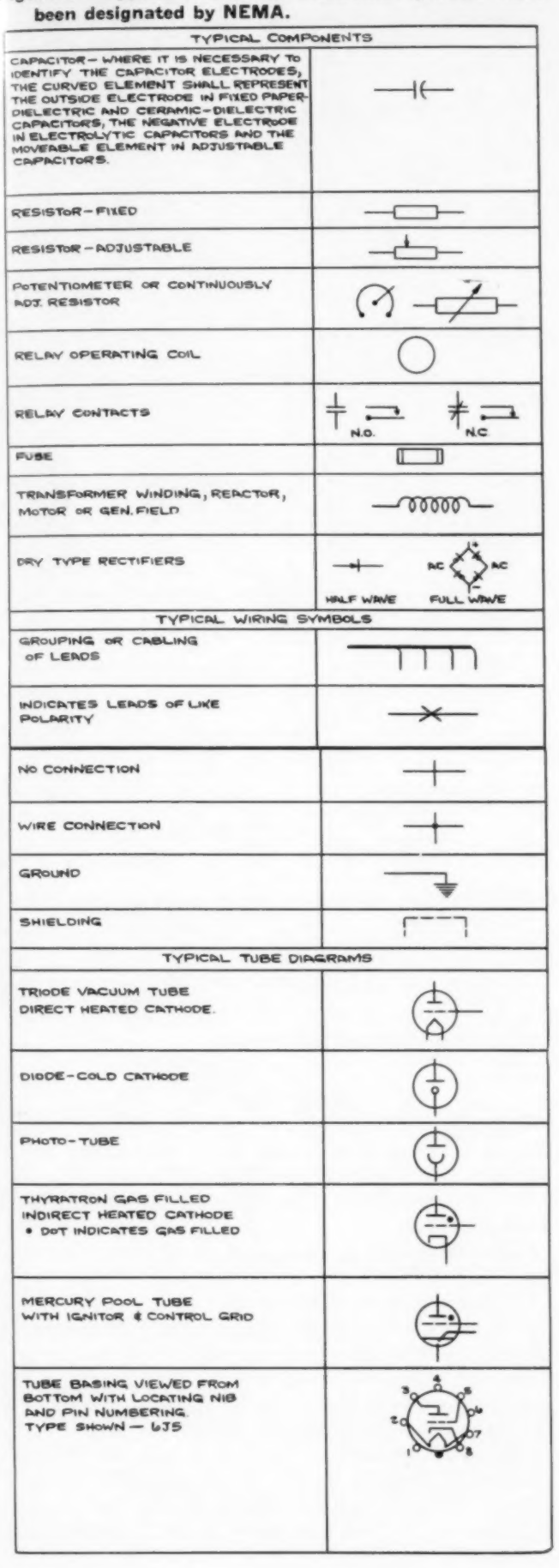
It is important that the equipment be checked for overheating immediately after the power has been disconnected and condensers discharged. Extreme care must be taken when checking such parts as tube envelopes which have very high operating temperatures. In some units these temperatures are so high that bad burns may result. Feeling the air adjacent to the component first is an excellent procedure to follow before actually touching the component itself.

Cleanliness — Periodic inspections of the unit for the presence of dirt and grime are very important. Parts, connections and joints, and especially the recesses of terminal connections, should be kept clean. Periodic cleaning of the equipment reduces the possibility of high voltage flashovers and poor connections due to dirt, corrosion and other foreign matter. Exposed parts will require more frequent cleaning than those enclosed in cabinets and the frequency of cleaning both will depend upon the type and degree of dirt present in the area.

Visual check of wiring and moving parts — The improper placement of wires and cables is a condition which may not interfere with the equipment performance but may eventually lead to a major breakdown. It is the general practice of the manufacturers of electronic equipment to cable wires together as much as possible, and to support them in such a way that they will not move appreciably. Vibration of the equipment

or handling of the wire may move the wire from its intended position causing it to rest on some component.

Figure 3 — Typical industrial electronic symbols have been designated by NEMA.


TYPICAL COMPONENTS
CAPACITOR — WHERE IT IS NECESSARY TO IDENTIFY THE CAPACITOR ELECTRODES, THE CURVED ELEMENT SHALL REPRESENT THE OUTSIDE ELECTRODE IN FIXED PAPER-DIELECTRIC AND CERAMIC-DIELECTRIC CAPACITORS, THE NEGATIVE ELECTRODE IN ELECTROLYTIC CAPACITORS AND THE MOVEABLE ELEMENT IN ADJUSTABLE CAPACITORS.
RESISTOR — FIXED
RESISTOR — ADJUSTABLE
POTENTIOMETER OR CONTINUOUSLY ADJ. RESISTOR
RELAY OPERATING COIL
RELAY CONTACTS
N.O.
N.C.
FUSE
TRANSFORMER WINDING, REACTOR, MOTOR OR GEN. FIELD
DRY TYPE RECTIFIERS
AC
AC
HALF WAVE
FULL WAVE
TYPICAL WIRING SYMBOLS
GROUPING OR CABLING OF LEADS
INDICATES LEADS OF LIKE POLARITY
NO CONNECTION
WIRE CONNECTION
GROUND
SHIELDING
TYPICAL TUBE DIAGRAMS
TRIODE VACUUM TUBE DIRECT HEATED CATHODE.
DIODE — COLD CATHODE
PHOTO-TUBE
THYRATRON GAS FILLED INDIRECT HEATED CATHODE • DOT INDICATES GAS FILLED
MERCURY POOL TUBE WITH IGNITOR & CONTROL GRID
TUBE BASING VIEWED FROM BOTTOM WITH LOCATING NIB AND PIN NUMBERING. TYPE SHOWN — 6J5

This may eventually result in a breakdown of the wire insulation due to wearing on the part, heat from the part, or a combination of these factors. When replacing wiring, make certain that the wires are replaced in their original positions.

All the components of electronic equipment should be securely mounted and connections firmly made. Vibration may cause screws, nuts and bolts to loosen, allowing parts to shift or fall out of place so as to affect the operation of the equipment. Screws, nuts and bolts should be tightened only when loose and care should be exercised not to tighten them beyond the pressure for which they are designed. Always use correct tools of the proper size.

Meter Observations and Circuit Measurements — Circuit measurements and meter observations for deviations from normal design conditions are an integral part of protective maintenance. Of special importance is the filament or heater voltages on the tubes. It is necessary that these voltages be held within the design limitations of the tubes, in order to have proper operation and long tube life. In general all voltages indicated on the manufacturer's schematic and wiring diagrams should be checked frequently for deviations and corrections made where inconsistencies are found.

With some types of equipment certain adjustments need to be made occasionally in order to maintain normal operating conditions. The instruction booklet supplied with the equipment by the manufacturer indicates these adjustments and the booklet should be studied before attempting any adjustments.

SERVICING FAULTY ELECTRONIC EQUIPMENT

Successful servicing depends on a thorough knowledge of the equipment. This knowledge should consist of how the electronic device operates and not necessarily the theory behind it.

It is recommended that the maintenance man become completely familiar with his equipment by studying the literature provided by the equipment manufacturers before attempting servicing. This literature often gives helpful hints for trouble shooting in addition to a general description of how the equipment functions.

It is not difficult to service defective electronic devices provided certain very simple procedures are followed. These procedures are based on a logical attack of the problem. The reasoning of cause and effect is most profitable to follow. Knowing the responsive action of one circuit resulting from the action of another will quickly help to locate the area of fault, and a step by step investigation of each circuit component will locate the exact cause of trouble.

There are, in general, two types of trouble encountered in faulty electronic equipment.

1. Partial operation.
2. Complete inoperation.

When the equipment has partial operation, the fault may be localized immediately to a circuit or area for investigation and inspection. However, when the equipment is completely inoperative, a different procedure must be followed, the object of which is to locate this area of fault. First, some very fundamental points should be checked. These are:

1. Line voltage and frequency.
2. Fuses.
3. All transformer voltages.
4. All external connections and equipment for proper operation.
5. Relays for proper operation.
6. Visual inspection of all parts as outlined previously in preventive maintenance.
7. Visual inspection of all tubes for burned out heaters or filaments.
8. Check of control settings to determine if trouble can be corrected by readjustments.

After these items have been checked, a more complete study of the various circuits and their components may be attempted. Perhaps the best method of attack for locating the area of fault is to divide the circuit into sections which perform some specific function. The most logical approach is to start with those circuits which are supplied by a transformer or signal voltage and continue from there to adjacent circuits. Of course for each circuit the maintenance man must know what tests to perform and what the results should be.

The measurement of voltage at various points in the circuit is probably the most important initial measurement that should be taken. A large percentage of the faults of electronic devices can be discovered by voltage measurements alone. If the voltage readings do not correspond to the values necessary, the reason must be determined. Some of the tests for basic circuit components are as follows:

1. Tubes may be tested most conveniently by replacing with known good tubes.
2. Resistors should be tested for continuity and correct resistance values while isolated from other circuit components.
3. Capacitors can be tested for shorts and their ability to store energy. Shorts may be detected by a continuity test. An open may be detected by impressing approximately 100 volts d-c across the condenser and then discharging it by shorting the terminals. A spark will indicate that energy has been stored. Qualitative measurements may be made by allowing the condenser to discharge through a known resistance and noting the rate of discharge. Comparison with correct values will determine if a condenser is good. As with resistors, condensers should be tested while isolated from other circuit components.
4. All coils, transformers or other windings should be tested for short or open circuits, grounds and proper resistance values.
5. The measurement of currents in the various circuits may be made for comparison with design data. Small discrepancies in the various individual components may add up and after amplification result in a much larger error.
6. When all the aforementioned tests fail to locate the trouble, a study of each circuit for discrepancies in wave form is in order. The circuits should be checked for correct wave form and for distortions. Certain phase relationships between circuits are sometimes necessary for proper operation. In these cases the instantaneous polarities must be checked.

Once the fault has been located, it is important to determine the reason the breakdown occurred. It might be due to the inability of some other component to function correctly or the faulty component itself might have fulfilled its life expectancy. If the inability of some other component to function properly is the cause of the fault, the situation will have to be remedied in order to eliminate the possibility of another early breakdown.

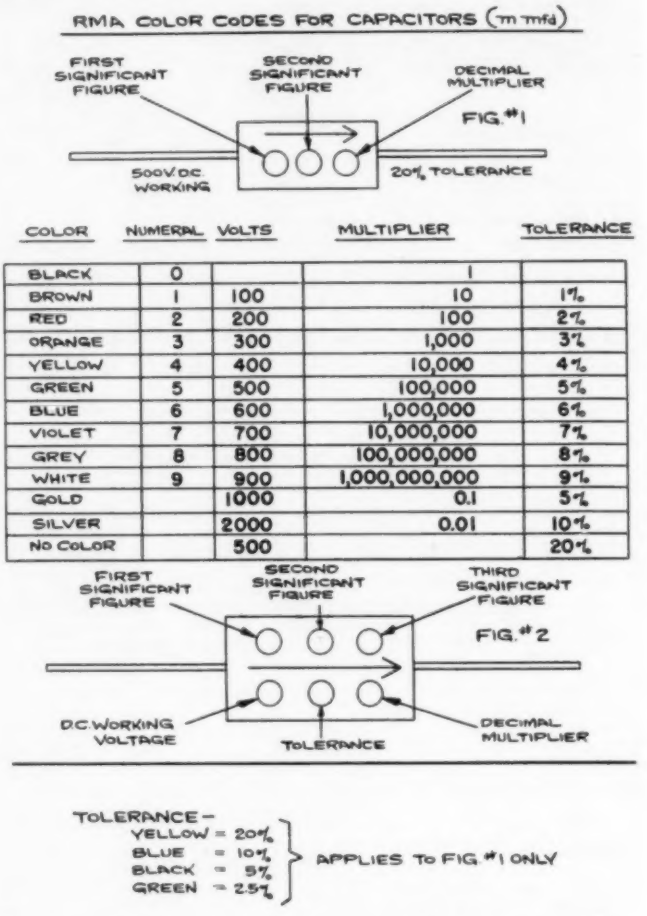


Figure 4 — Color codes have been set up to aid in working on capacitors.

If the faulty component itself has fulfilled its life expectancy, then a record will be available for future reference concerning replacements.

SPARE PARTS

In order to perform maintenance successfully it is necessary that a spare parts inventory be kept. Several factors determine just what items should be included in this inventory.

1. Expectant life of component parts.
2. Availability.
3. Allowable expenditures.

Recommendations of the manufacturer of the electronic equipment and past experience with electronic equipment will also be an aid in determining spare parts. It is a wise policy to test all spare parts when received to see that they are in a usable condition.

A complete understanding of the equipment, its circuits and application, together with experience in working with electronic equipment will provide time saving shortcuts in the maintenance of industrial electronic equipment.

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Maintenance Superintendent
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Langeloth, Pa.

MAINTENANCE EXPERIENCE ON 600-VOLT RECTIFIERS

By ROBERT T. LUCAS
Electrical Superintendent

and

H. K. FISH
Electrical Foreman, Strip Steel Dept.

Weirton Steel Co.
Weirton, W. Va.

. . . . maintenance experience on 600-volt rectifiers has been very gratifying . . . .

▲ BACK in 1940 a program was instituted at the Weirton Steel Co. for widening out and speeding up the original 1928 installation of the 48-in. hot strip mill. An additional finishing stand was proposed with increased horsepower on the driving motors of all of the stands. This necessitated an increase in the 600-volt, d-c power supply. The 600-volt d-c power was supplied by six 1500-kw, generators driven by three 4200-hp synchronous motors.

Due partly to the large amount of synchronous capacity and also to the higher efficiency of the rectifiers over additional motor generator sets, it was decided to purchase two 3500-kw rectifiers to supply the additional 600-volt power required. All of the equipment necessary to rebuild the 48-in. hot mill was ordered, drawings completed, and the program was about to be started when war was declared. That stopped the rebuilding program due to the fact that the Weirton Steel Co. could not shut down for the time necessary to complete this changeover.

All of the equipment remained in storage at the Weirton Plant, until with the increased loading on the motor-generator sets due to increases in production, and also due to the high cost of maintaining the old breakers and the generators, it was decided to install the two 3500-kw rectifiers along with the new type breakers for the motors and generators in 1945.

There had been electrical engineering advances in the control for rectifiers since ours were purchased and the control cubicles were returned to the factory for an incorporation of the latest design.

An addition to our substation was constructed to house the rectifiers and a temporary location in the basement of the present substation was used to set up the new motor and generator breakers. This entire installation of the rectifiers, breakers, and the cutting over of the motors and generators to the new breakers was accomplished without any interference to the rolling schedules of the 48-in. hot mill.

When the new rolling stands were installed and the mill widened out in December of 1947, this work done in 1945 was a big factor in shortening the time of the final shutdown.

The two 3500-kw rectifiers are connected through breakers to the 600-volt bus on which are connected the six 1500-kw generators. The mill motors are started with Ward-Leonard control on the generators. At 450 volts on the bus, the rectifier breakers close and they advance their firing up to 600 volts along with the generators.

A drop, taken across No. 1 generator commutating field, is fed to a field of a rotating regulator. This controls the firing of the ignitron tanks and is set to give a 2½ to 1 ratio of the ampere load of No. 1 generator. Thus at 2000 amp on No. 1 generator, the rectifier load will be 5000 amp.

The control is so arranged that in the event of No. 1 generator breaker going out, the signal for the amplidyne field is automatically transferred to No. 2 generator and so forth, up to generator No. 6.

Each 600-volt rectifier consists of a 4240-kva transformer, as shown in Figure 1, with a 6700-volt primary with a tap changing arrangement on the secondary winding from 525/614 volts. The transformers are 12 phase. One end of each phase of the secondary winding is connected to a commutating reactor, from there to a high speed anode breaker, and then to the ignitron tank. The anode breakers and commutating reactors are

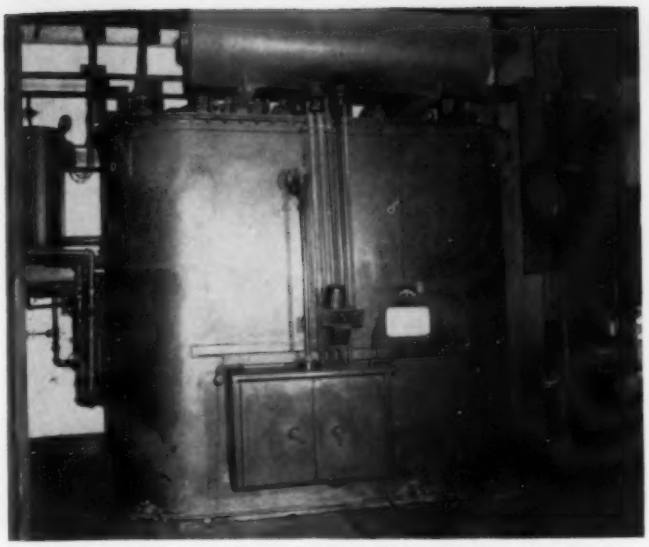


Figure 1 — Current for the 600-volt rectifiers is stepped down from a 4240-kva transformer with a 6700-volt primary.

Figure 2 — Each rectifier has 12 ignitron tanks.

located on a framework in back of the transformer. The 6900-volt control transformer is located at the upper left. The tap changer is shown on the front.

The transformers are of the oil cooled type with water coils inside the tank to cool the oil. A general arrangement of the piping is shown at the left. The transformer cooling coils are backwashed every ten days. This is accomplished with the rectifiers in service. It takes one man about one and one-half hours to complete the backwashing of the cooling coils of both transformers. The valving is so arranged that the flow of water through the cooling coils is reversed and at the same time air is injected into the water. This agitation of the backwash water loosens the sediment build-up and carries it out to the sewer. A sight gage is located in this line as shown to give a visual inspection of the condition of this backwash water. When the water becomes clear, the cleaning job is completed.

Also located in the back of the transformers are the current limiting reactors. We originally had considerable trouble with these due to improper design and have changed 12 reactors. The present design gives no trouble.

We experienced a main water line break which caused the following repairs.

1. Replaced one commutating reactor.
2. Changed four anode breaker closing motors.
3. Changed 12 anode breaker holding coils.
4. Installed 12 anode breakers on new slate.

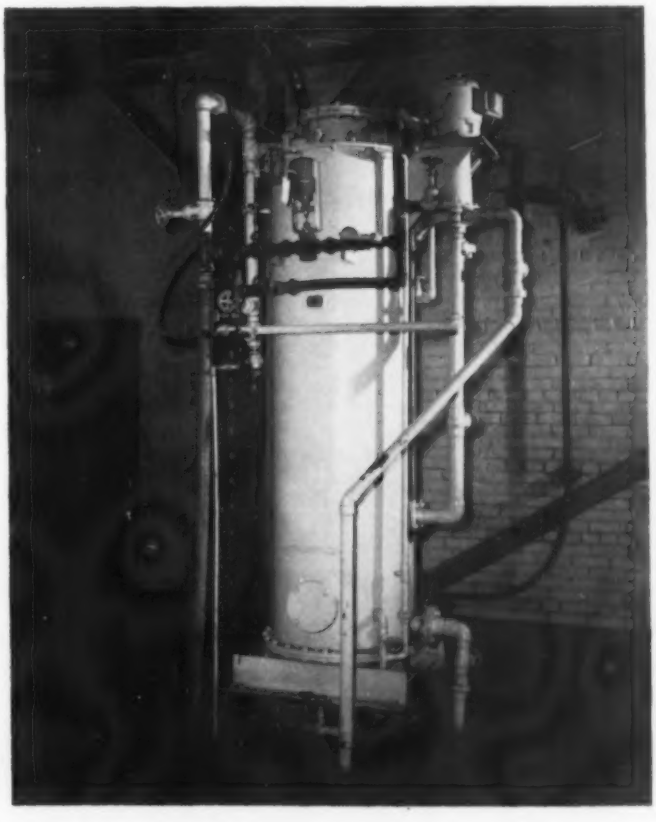
The anode breakers require cleaning and a thin film of grease on the hinge pins every two months. It requires two men, 16 hours each, to clean and lubricate the 24 anode breakers.

Each 3500-kw rectifier has 12 ignitron tanks, as shown in Figure 2. The control is so arranged that in the event of trouble or for maintenance on any of the tanks half of them may be operated at half the rated load.

A program was initiated in 1950 to change the rectifier tanks for inspection and clean-up. However, when these tanks were opened, they were found to be in good condition. It was not deemed necessary to change any more of the tanks. We do not have many arc-backs since the tanks have aged. We have four to six per year with none in the past three months.

Shown in the center of Figure 2 is the rotary vacuum pump. These pumps are run continuously. In the past six and one-half years two of these pumps have been sent back to the factory for inspection. At the top of Figure 2 is the mercury condensation pump. These pumps originally were cooled by a small amount of river water flowing through a cooling tube. On one of the rectifiers, this cooling system plugged up due to river water sediment, causing the heater unit to short. It was necessary to change this condensation pump.

Figure 3 — Cooling is accomplished through a water-to-water heat exchanger.



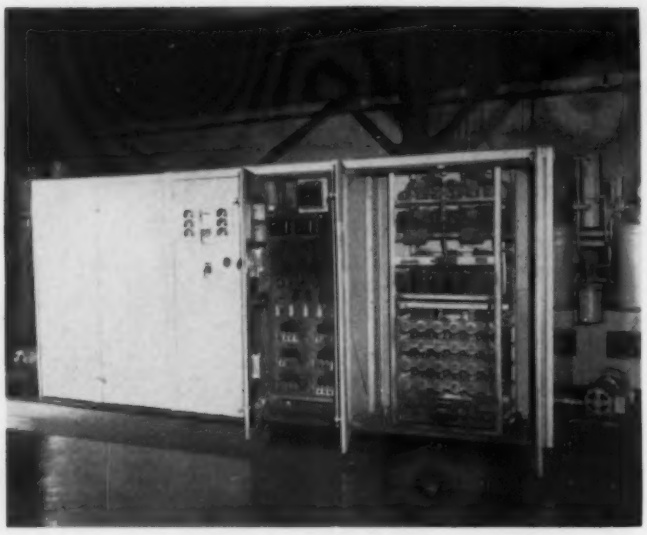


Figure 4 — This control center handles No. 2 rectifier.

Figure 5 — Nothing but regular breaker maintenance has been required on the rectifier bus reactor.

Subsequently, this water supply has been changed from river to city water. We have had no more failures of this kind and there is no maintenance required on these pumps.

The rectifier tanks are cooled by a closed recirculated water system. There is approximately 350 gal of distilled water in this closed system which is treated with sodium dichromate. One to three gallons of distilled water per month is added to each rectifier tank cooling system due to evaporation. This water system requires no maintenance other than adding this water and greasing the water pump motor.

The water in this system is cooled by a water-to-water heat exchanger, as shown in Figure 3. At the top right is the recirculated system water pump. The heat exchanger is the vertical tube type mounted on insulators. River water through a $\frac{1}{32}$-in. filter screen is admitted to the heat exchanger. These connections are of rubber hose. The temperature of the recirculated water is maintained at approximately 45 C by means of a temperature regulating valve operating on the flow of the river water. This valve is shown at the top of the heat exchanger.

The maintenance on these heat exchangers entails exposing the ends of the tubes through which the river water flows and cleaning these tubes by a wire brush attached to a rod. This removes the sediment deposited on the tubes by the river water. It requires two men, sixteen hours to clean the two heat exchangers at six-month intervals.

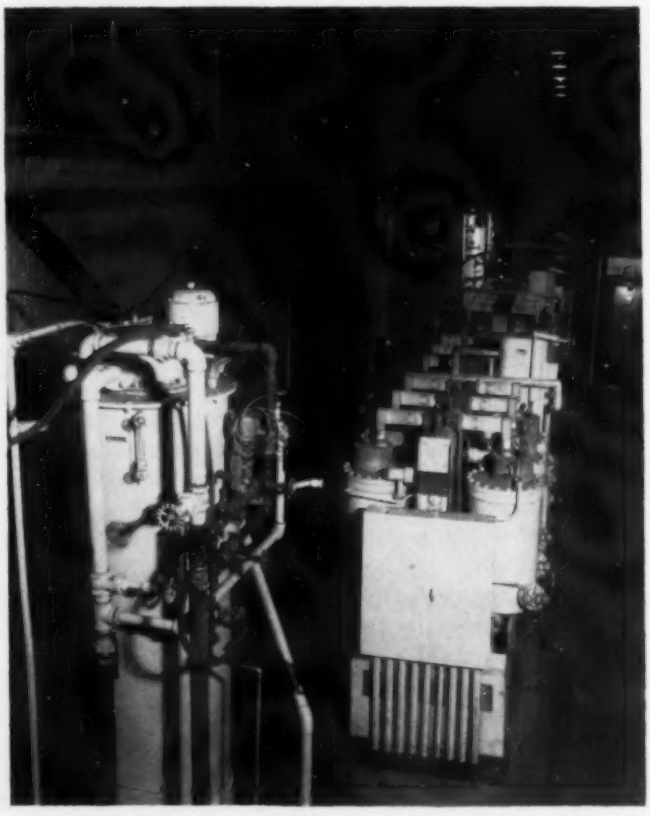
The water regulating valves have each been changed once due to river water corrosion. The water hose on the heat exchangers have also been replaced.

Figure 4 shows the control units with the doors open on the units controlling No. 2 rectifier. The control voltage and three-phase power is supplied by the 37½-kva transformer with a 6700-volt primary and 220-volt secondary as was shown in Figure 1. The unit at the right is the control for firing the rectifier tanks. The unit at the left contains the starting equipment for the rotary vacuum pump, mercury condensation pump, rotating regulator set, recirculated water system pump, and related a-c equipment. The rotating regulators for controlling the firing of the rectifiers are shown at the ends of the control cubicles.

Normal maintenance on a-c equipment such as contact replacement, shunts, etc., is performed on the a-c panel. The auxiliary transformers, reactors, selenium rectifiers and capacitors shown in the cubicle on the right have required no maintenance.

Figure 5 shows a view of No. 2 rectifier bus reactor, the rectifier negative breaker, the loading reactor mounted on the wall with the dummy load resistor just shown in back of the bus reactor. No maintenance other than regular breaker maintenance has been experienced on this equipment.

Figure 6 — View shows the two rectifiers and their heat exchangers.



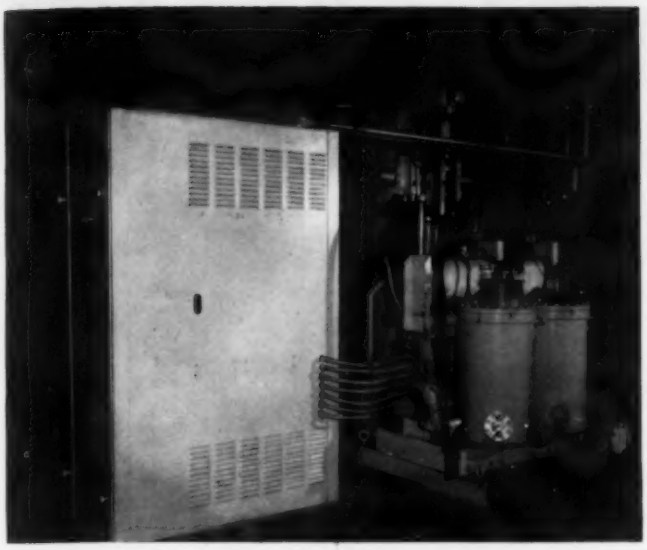


Figure 7 — The rectifier tank conditioner keeps two spare tanks evacuated at all times ready for use.

Figure 6 shows a general view of the two rectifiers with their heat exchangers. At the far end is located a rectifier tank conditioner. Figure 7 shows a close-up view of this conditioning unit. Two spare tanks are kept evacuated at all times, ready for use. We have at our open hearth substation, two 1000-kw, 250-volt rectifiers for auxiliary d-c power and this conditioner has adaptors to condition these 250-volt smaller tanks.

The following spare equipment is kept on hand for these two rectifiers.

1. Heat exchanger complete.
2. Two ignitron tanks.
3. Assortment of control transformers, reactors, selenium rectifiers and capacitors.
4. One commutating reactor.
5. Two current limit reactors.
6. Two anode breakers.
7. Two anode breaker closing motors.
8. One mercury condensation pump.
9. One rotary vacuum pump.
10. One rotating regulator.

Our experience with these rectifiers has been very good. The maintenance that they have taken over the past six and one-half years leaves a good taste in the mouths of our strip steel maintenance men. One of our strip steel foremen has indicated that he would like to have all of the drive motors made rectifiers. This perhaps is a challenge to the genius of the electrical design men. I know this would have a hearty welcome in the steel mill field.

DISCUSSION

PRESENTED BY

A. SCHMIDT, JR., Power Rectifier Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

C. R. MARCUM, Manager, Rectifier Engineering Section, Generator Engineering Department, Westinghouse Electric Corp., East Pittsburgh, Pa.

SAMUEL HELLER, Chief Engineer and Independent Consultant, American Rectifier Corp., New York, N. Y.

C. O. FRANKLIN, General Supervisor, Electrical and Engineering Department, United States Steel Corp., Munhall, Pa.

DONALD C. NELSON, Electrical Engineer, Jones and Laughlin Steel Corp., Aliquippa, Pa.

H. K. FISH, Electrical Foreman, Strip Steel Dept., Weirton Steel Co., Weirton, W. Va.

A. Schmidt, Jr.: The experience in cleaning these rectifiers is interesting. Mr. Fish stated that he opened up a few of these rectifiers for cleaning and found they were so clean that he did not have to do anything with them. Based on experiences of other users of rectifiers who operate them continuously in the chemical industry, we have estimated the cleaning interval for industrial rectifiers with relatively intermittent use is probably on the order of 15 to 30 years.

I think the Weirton Co. is to be congratulated on the pioneering spirit with which they have gone into the use of rectifiers in service where the utmost reliability is required, at a time when the reliability of rectifiers had not been as well proven as it is now. The extent to which the use of rectifiers in this kind of service has grown is indicated by the business which our company has done since this installation. There are now two installations in hot strip mills where all the power is supplied by rectifiers and which have been in operation for a year or more. There is another such installation being made at the present time. Still another installation is being made where the rectifiers are paralleled with existing motor-generators to increase the capacity of a strip mill.

There are also two tube mills in operation and another being installed, and there is a skelp mill being installed, all powered entirely by rectifiers. Other manufacturers, both here and abroad, have also supplied rectifiers for main roll drives.

Mr. Lucas mentioned the fact that these rectifiers were modernized after they were ordered and before they were installed. The modernization was almost like changing from a 1915 model automobile to a 1935 model. The 1952 model has been improved somewhat over the 1935 model, but not nearly so much. I would like to describe two of the major improvements that have taken place in the last few years. These are not important enough to require the customer to throw out as scrap his old rectifier, but they do represent improvements in performance and maintenance.

The first of these improvements is the use of a static magnetic voltage regulator. The rotating regulator has been in use as a regulator for a good many years. The magnetic amplifier is a static version of the rotating regulator.

Figure 8 shows an installation of rectifiers at the plant of the Detroit Steel Co. in Portsmouth, Ohio, consisting of two 5000-kw rectifiers. It shows the rectifiers, transformer, anode breakers, and auxiliary rectifier controls. The second rectifier is in the background. This is the highest output rating of any industrial rectifier of this voltage level.

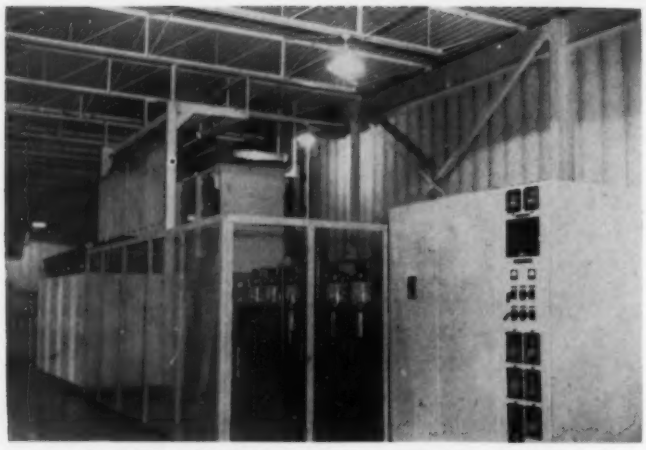


Figure 8 — This 5000-kw rectifier supplies current to a 54-in., 4-stand, tandem, hot strip finishing mill.

Figure 9 shows the magnetic regulator for this rectifier together with its associated control circuits.

Figure 10 shows the wiring diagram of the magnetic regulator and the control system. Here are the rectifier transformer, the rectifier, and the firing circuit which fires the igniters. The firing circuit is controlled by

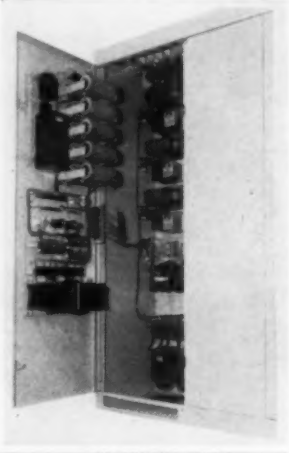
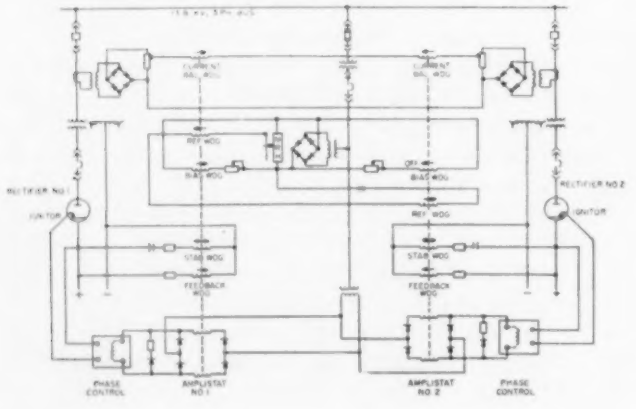


Figure 9 — Close-up view shows voltage regulator and excitation compartment for a pumpless ignitron rectifier.

phase-shifting d-c windings in a manner similar to the field of a generator; i.e., increasing current in the phase-shifting windings results in increased output voltage from the rectifier. The current in these windings is controlled by the regulator which consists of two saturable reactors and has two main control windings. One is a reference winding supplied by a constant reference

Figure 10 — Schematic diagram of magnetic regulator circuits for two 5000-kw rectifiers.



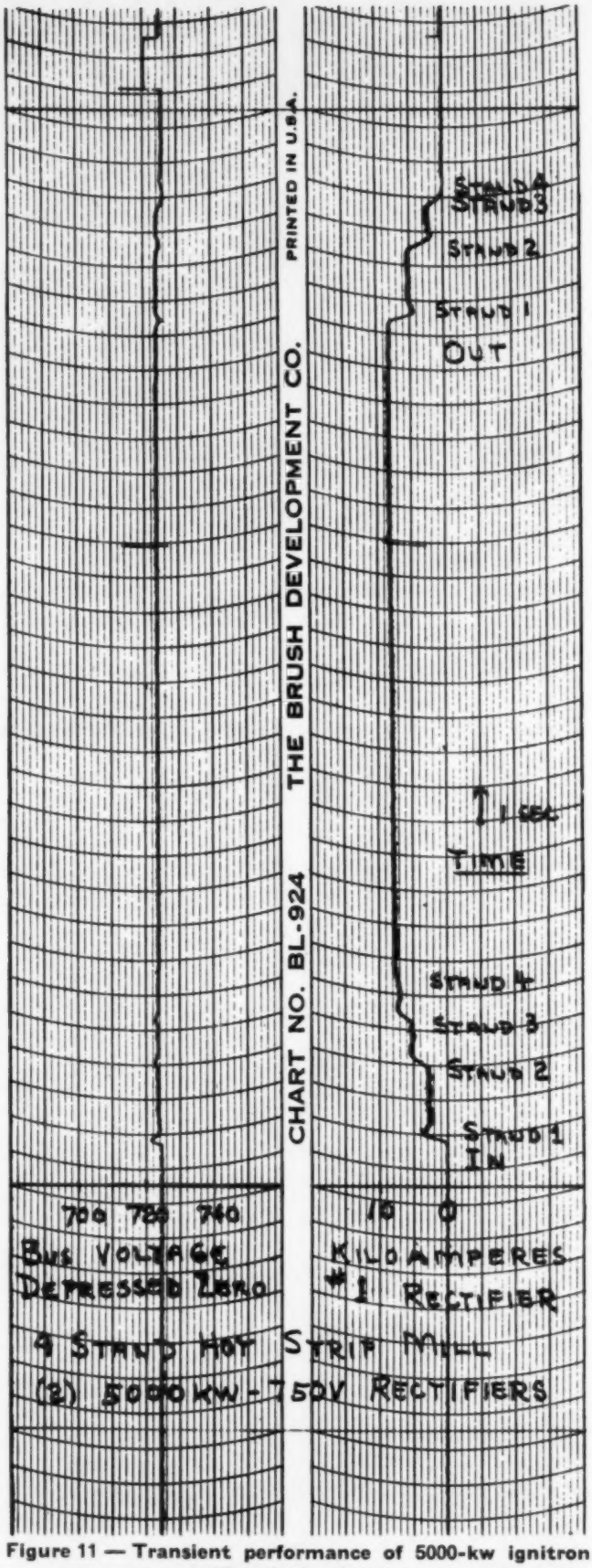


Figure 11 — Transient performance of 5000-kw ignitron mercury arc rectifier obtained with a magnetic amplifier type regulating system.

source, while the other is a feedback winding. These windings correspond to control fields of a rotating regulator.

In addition, there are current balance windings con-

Figure 12 — The six-anode pumpless rectifier shown is very compact.

nected to the current input, and these balance windings see to it that the rectifiers share the load.

Figure 11 shows the performance of the magnetic regulator. The left-hand chart shows the current in one rectifier. Increasing current goes to the left. The maximum load is about 120 per cent of the rating of the rectifier.

The voltage chart is shown at the right and has a suppressed zero. Each of the major lines represents ten volts. This is a 750-volt rectifier. Thus, you can see that the voltage is varying 2 or 3 volts while the metal is going through the mill. This type of regulator not only improves the performance of the rectifier but has minimum maintenance because there are no moving parts, and no brushes or bearings to worry about, as there are in a rotating regulator.

Another important advance that has taken place in the last few years consists of the pumpless rectifier. The pumpless rectifier is a term that is used to distinguish this form of rectifier from the sealed rectifier. The permanently sealed rectifier has been made in small sizes for a very long time. The pumpless rectifier is a modification of the higher rated pumped rectifier, where most of the joints are welded instead of bolted, and careful attention is paid to the evacuation of the rectifier and treatment of all the internal parts. The rectifier is permanently sealed off, but it can be readily opened up for cleaning and renewal of parts, if necessary, by the manufacturer. These rectifiers have been in service a maximum of about four years and the results have been very encouraging, as evidenced by sales of over 50,000 kw in capacity.

Figure 13 — This pumpless rectifier d-c unit substation is rated 1000-kw, 250-volt, from 6600-volt, 3-phase, 60-cycle current.

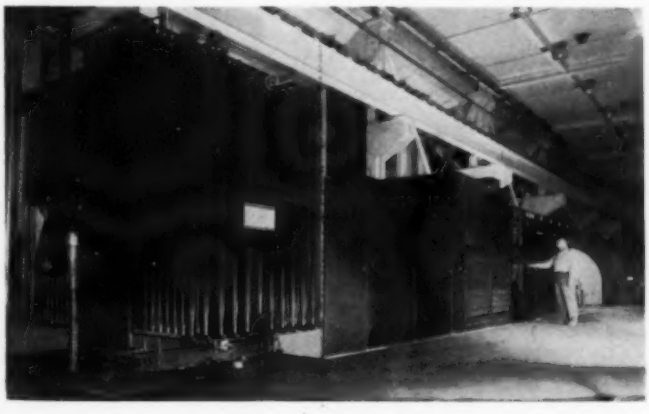


Figure 12 shows a view of a six-anode pumpless rectifier which is much more compact than the pumped rectifier with the same number of anodes. The mounting is somewhat similar to the mounting of a sealed rectifier. The auxiliaries are contained in the rear of the enclosure and there is a small hoist for installation and removal of the rectifiers if it ever becomes necessary.

Figure 13 shows an installation of a complete pumpless rectifier equipment. It shows the transformer, anode breakers, an enclosure with the rectifiers themselves, d-c control, and the d-c feeder breakers. This pumpless rectifier equipment is installed at the Jones and Laughlin Aliquippa plant. It represents the latest improvements in rectifiers. It eliminates a certain amount of maintenance, in that the vacuum pumps have been taken out and there is no maintenance on these. We still have water pumps and probably will have them as long as we make rectifiers of this size.

We look forward to still further improvements in the art, but it probably will be like our 1952 automobiles, we will not see the advances in ten years that we have seen in the last ten years and the ten years before that.

C. R. Marcum: We note that the authors have done an excellent job of maintaining their equipment and keeping records.

As a further note, to give you a maintenance comparison, "Rectifier Applications on Steel Mill Drives," by George B. Scheer, 1952 Proceedings of the AISE, p 693, compares a 1000-kw, 250-volt, motor-generator set with a rectifier of the same rating, and the comparison is about as follows: The down time per year was 76 hours for the motor-generator set against 46 hours for the rectifier. The maintenance labor cost per year was $558 for the motor-generator set and $197 for the rectifier. Material costs were $125 for the motor-generator set and $115 for the rectifier. Mr. Scheer had a note that most of $115 for rectifier material was for distilled water.

AIEE made a combined report of the installations of all the manufacturers of rectifiers, and up to January, 1952 there were either installed or on order 600,000 kw of rectifiers in industrial service. At the present time, there are roughly 150,000 kw used for main roll drives. These are either all rectifier drives or rectifier additions to existing motor-generator set drives.

Mr. Schmidt discussed the pumpless type of rectifier. On one particular electrochemical installation, consisting of 60 rectifiers, accurate records have been kept and the maintenance of the vacuum system for each rectifier requires 12 man-hours per year. The vacuum system maintenance is so small that it seems inconsequential when compared to the outage time and expense of reconditioning pumpless tubes. The heat exchanger maintenance required 12 man-hours per year, the switchgear required 30 man-hours per year, and all

other devices in the station required 65 man-hours per year.

Our company makes two types of rectifiers. One is the sealed tube type which has leakproof seals, glass to metal seals, throughout. The tube is made of a non-corrosive steel to prevent vacuum leakage. The other type is a pumped tube which is evacuated continuously. This tube can be opened and repaired in the field. We have felt that a tube half way between the pumped and the sealed tube is not practical. The larger sealed tubes can be opened and repaired at the factory.

Samuel Heller: We manufacture selenium rectifiers, which is entirely different. So far there are several 300 and 500-kw units in the field, mostly 275 volts for mine and steel mill service. We do not use any electronic tubes for control.

C. O. Franklin: I was interested in the transformer used with the rectifier at Weirton, and would like to ask Mr. Lucas why a water cooled transformer was selected for this job? Also I would like to ask the size of that transformer?

H. K. Fish: That transformer in the figure is about 14 feet high and possibly ten feet across the face of it.

A. Schmidt, Jr.: These transformers were made water-cooled to save space. The figure did not show the place where the transformers were installed, but they were very tight. There was not room for self-cooling radiators in that location, and that is the reason for the water-cooling.

The kva of the rectifier transformer is always larger than the kw rating of the rectifier, in a ratio of about 120 or 125 per cent. So, with this 3500-kw rectifier the transformer rating is about 4300 kva.

The other question brought up had to do with the pumpless rectifier. There is a demand in some quarters for simplification of the rectifier, and particularly in places where single rectifiers are installed, and where there is not the maintenance skill that there is in multiple rectifier installations. The pumpless rectifier simplifies maintenance, since less maintenance skill is required. And, while the installation of these units has not been extensive so far, the experience to date has been, as I say, very promising.

Donald Nelson: I was interested in the comment about cleaning the tubes of the heat exchanger. The author said it took two men 16 hours, and from that picture I take it they were upright. How do you clean those tubes?

H. K. Fish: We remove the top cap of that heat exchanger and the tubes are just inside the top of that heat exchanger itself. Then there is an opening at the bottom also, in the side of the heat exchanger. By opening that cap on top and taking wire brushes on long rods, the men get up on top of it and shove these rods up and down through that until it is clean. At the same time, they run water through in order to wash the dirt out the bottom. It is just river water going through and the corrosion from river water itself builds up sediment on the tubes. This has to be cleaned about every six months in order to keep the rectifiers themselves cool.

We try to hold our rectifiers to about 45 C. At that temperature we do not have arc-backs. However, as the temperature goes above, say, 50 C, then we will start having arc-backs. We have had no arc-backs in the last three months and we do not have over probably four to six per year, because of the close control of the temperature on this heat exchanger itself.

Donald Nelson: From the figure I could not tell how much height you had in the building. The heat exchanger looked like it must have been 12 or 13 feet high and you have to have quite a height above that then for your rods, do you not?

H. K. Fish: We do. Our building is about 32 or 34 ft high.

DETROIT STEEL CORPORATION STARTS SECOND BLAST FURNACE AT PORTSMOUTH, OHIO

▲ THE nation's pig iron capacity was raised by 500,000 tons annually on August 27, when Max J. Zivian, president of Detroit Steel Corp., gave the signal starting the company's new 1400-ton, No. 2 blast furnace at its Portsmouth division. This completes another step in its $60,000,000 expansion program. Final steps in the current modernization and expansion program at the Portsmouth division will be completed early next year, and will rank Detroit Steel about fourteenth among large integrated steel producers.

The program includes installation of four 250-ton open hearths, new circular type soaking pits and a 48-in. high-lift blooming mill and other related facilities. When these are installed early next year, Detroit Steel's Portsmouth division will be able to produce and process 1,300,000 net tons of steel ingots, or its steel making capacity will be doubled from the present level of 650,000 tons.

No. 2 blast furnace stands 238 ft above the ground, and has a hearth diameter of 28½ ft. It gives Detroit Steel its second furnace and triples its pig iron capacity from the present level of about 250,000 tons annually to over 750,000 tons.

The furnace was named "Louise" after Mr. Zivian's eldest daughter. Old "Susie," Portsmouth's No. 1 furnace will now be relined and rebuilt after more than ten years continuous operation. During this period it turned out over 2,600,000 tons of pig iron which is believed to be a record.

Previous steps in the expansion program included the installation of a 54-in. hot strip mill and a 54-in. cold rolled sheet and strip mill. Both began operating in 1952.

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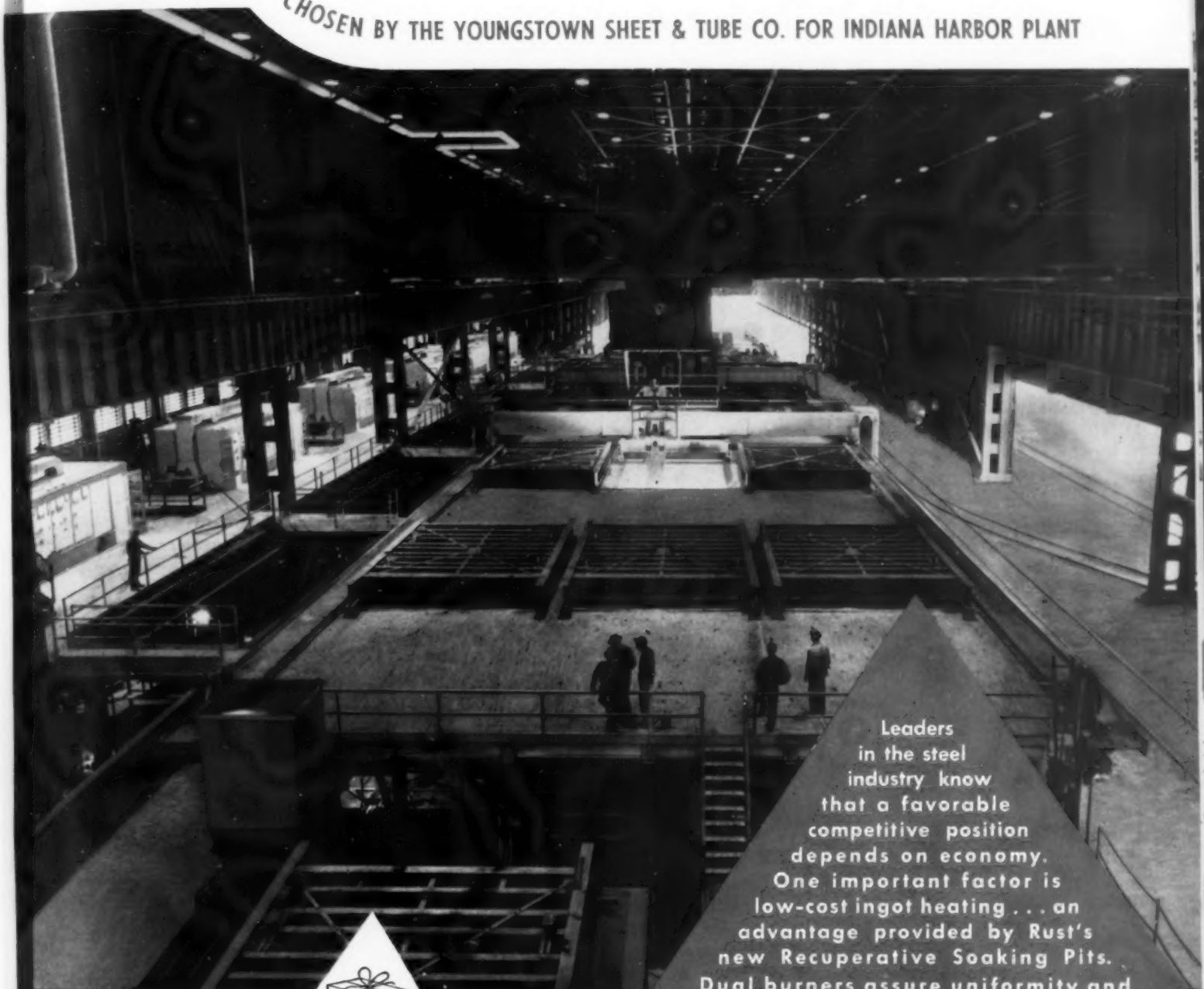
CHOSEN BY THE YOUNGSTOWN SHEET & TUBE CO. FOR INDIANA HARBOR PLANT



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Rust builds furnaces for every metallurgical heating need

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RUST BUILDING • PITTSBURGH, PA.

By HAROLD GASSNER, Vice President, Rosedale Foundry and Machine Co., Pittsburgh, Pa.

ECONOMIES EFFECTED IN ROLLER GUIDE APPLICATIONS

▲ ALTHOUGH the use of roller twist guides has been standardized on billet, bar and rod mills throughout the country, the selection of materials for this application is still made from a wide variety found in use today. Cast iron, alloy steel and cast high alloys are several of the more widely used materials, and it is not surprising to find rollers of different compositions on the same mill. The service conditions under which rollers must operate are of such severity that a life of several weeks is considered excellent in many cases. Stress, heat shock and wear result in failure through heat checking, deep grooving and less frequently, fracture.

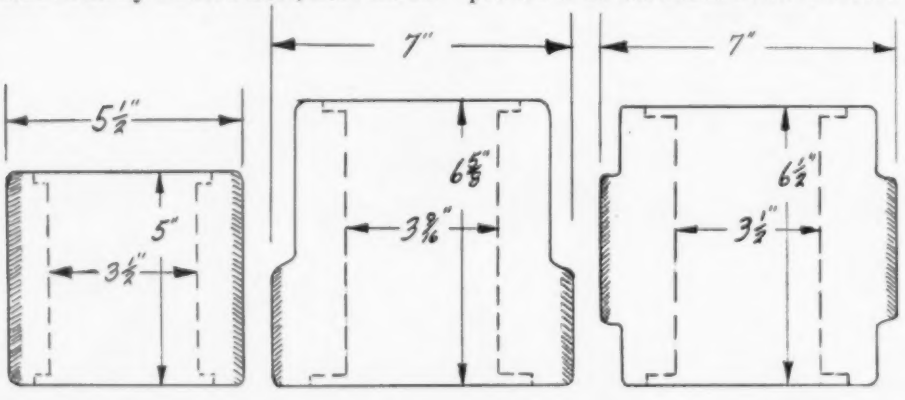

Figure 1 — This sketch shows three types of rollers in use at the Aliquippa Works. At left is original type roller used on 18-in. mill which permits reversal. Rollers at right are used on 21-in. mill. Shaded areas indicate chilled wearing faces.

At the present time, excellent tonnage is being obtained with Meehanite type GM rollers at the Aliquippa, Pa. works of the Jones & Laughlin Steel Corp. The rollers are being used on 21 and 18-in. mills at the billet and bar mill of the works which are operated in line with the blooming mill.

The first pair of Meehanite rollers used at the mill were supplied by the Rosedale Foundry & Machine Co., Pittsburgh, Pa., early in 1951. They were installed on the 18-in. single strand billet mill along with manganese steel and cast high alloy rollers — tonnage records were carefully kept to determine the ultimate service of each. The design of rollers used on this mill is such that they can be reversed since steel runs on only half the face at a time. There is no provision, however, for adjusting the guides to compensate for wear.

The maximum tonnage obtained from the cast high alloy and manganese steel rollers, with reversal, was 19,000 tons. The Meehanite rollers proved to be best suited with a record of 22,000 tons before reversal. After reversal, the same rollers were giving good service at 55,000 tons — three to four times more tonnage than with any other material tested. First cost of the Meehanite rollers was ⅔ that of the least expensive material and only ⅓ that of the high alloy materials. Combining these facts indicates that, even disregarding downtime and change-over costs, use of the Meehanite rollers meant total cost reduction of up to 90 per cent. As a result of this test, Meehanite rollers were also installed on a 21-in. roughing mill; a single strand, two-high, six-stand mill receiving 8 × 8's from the blooming mill. This mill is set up for three passes as follows:

Inside	Center	Outside
8 × 8	8 × 8	8 × 8
to	to	to
4 × 4	6⅜ × 5	5 × 5

The 4 × 4-in. billet rolled from an 8 × 8-in. bloom on the 21-in. roughing mill offers a very good idea of the heavy service requirements which these rollers must meet. Three twists are made after the first, third and fifth stands. Roll pass dimensions are:

1st Stand	8 × 8 to 6¼ × 8½
	90 degree twist
2nd Stand	6½ × 6½
3rd Stand	5⅛ × 7⅛
	90 degree twist
4th Stand	5⅛ × 5⅛
5th Stand	3⅞ × 5½
	90 degree twist
6th Stand	4 × 4

Operating space does not permit mounting three sets of twist guides on the same rest bar after each pass on these 18 and 21-in. mills. On the 21-in. mill, guides for the outside and inside passes are mounted on one rest bar, center pass guides are mounted on another. Guides for each of the three passes on the 18-in. mill are mounted individually.

Manganese steel rollers are still used to some extent on the roughing mill, since take-up adjustments here permit removing the rollers, regrinding and replacing. Approximately ⅝-

Figure 2 — Rough roller casting at left, machined roller at right. Wearing faces are ground at the mill. All rollers are mounted on fabric bearings.

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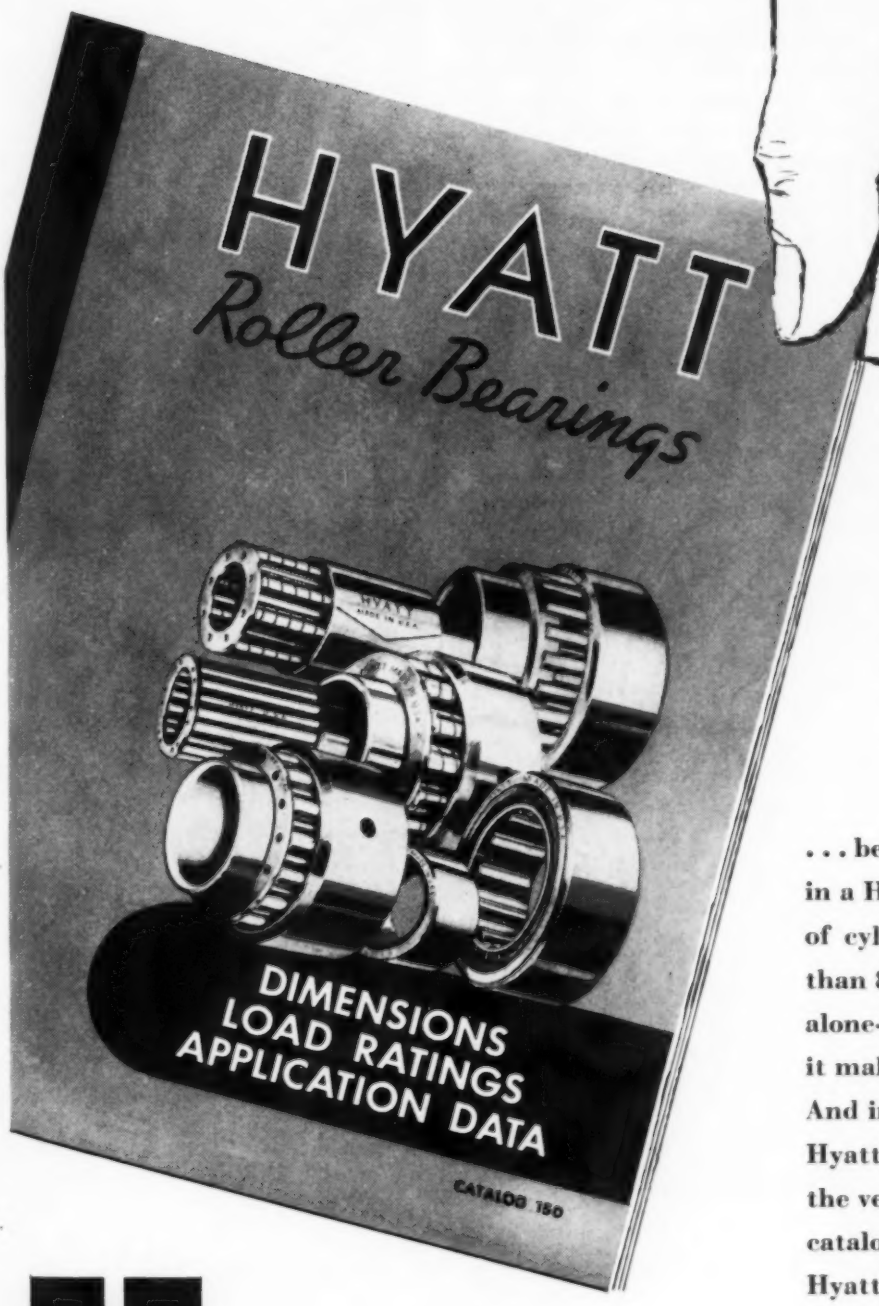

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HYATT ROLLER BEARINGS

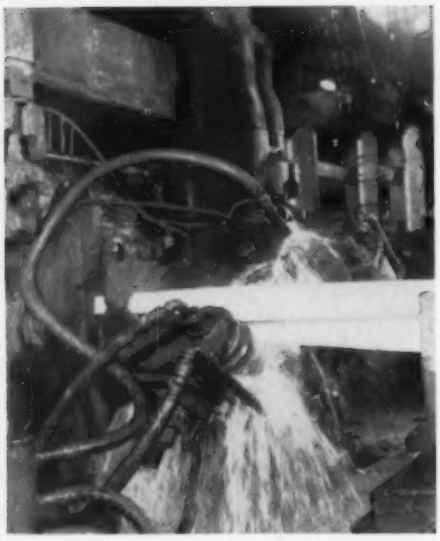

Figure 3 — 5⅛ x 7⅛-in. billet is being twisted between third and fourth stands of 21-in. roughing mill. Rollers must carry all stresses set up in twisting this billet after initial twist is made by flat guides.

in. wear on diameter can be compensated for in this manner. With this method, manganese steel provides service almost equivalent to the Meehanite rollers which are not reground. Costwise this means savings resulting from use of Meehanite in first cost, change-over and downtime, and regrinding.

Regrinding is but one method used to increase roller life — particularly where expensive alloys are being used. For example, one large steel mill was using an expensive alloy material for rollers; in order to extend overall service life, rollers were resurfaced by welding after deep grooving occurred. Then after the resurfaced area wore away, rollers were ground to operate on stands with smaller roll pass dimensions requiring smaller diameter twist rollers. Meehanite rollers on this same mill gave good service up to 70,000 tons in some instances and at far lower initial cost. Maintenance costs were also greatly decreased since these rollers were not resurfaced but only reversed.

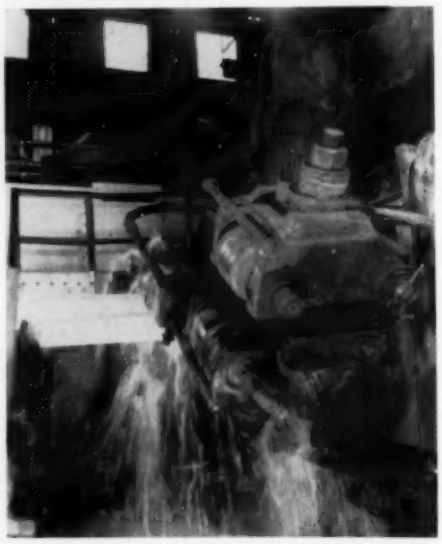

Figure 4—Same strand shown in Figure 3 illustrates mounting of inside and outside twist guides on same rest bar.

TROLLEY CHANGEOVER INCREASES ORE BRIDGE CAPACITY

By A. L. WILLIAMS
Engineer
Crane and Bridge Dept.
Engineering Works Div.
Dravo Corp.
Pittsburgh, Pa.

▲ FOR 32 years, the Granite City Steel Co. relied on a large materials handling bridge to supply its blast furnaces with ore, coke and limestone, and to handle stock coal for the coke ovens. Increased production schedules made it apparent that the ore bridge could not keep the stock bins filled. Structurally, the bridge was in good shape, but the man trolley that handles the bucket was inadequate for the job.

To solve the problem without building a new bridge, Granite City had Dravo Corp., Pittsburgh, design and construct a new lightweight man trolley. The new trolley handles a 12-ton capacity bucket while the original trolley on the bridge was designed for a 7½-ton bucket, although the company had been using a larger bucket for some time. To reduce the weight of the new trolley to a minimum, liberal amounts of aluminum and alloy steel were used in its construction. This resulted in a reduction of 35,000 lb as the old trolley weighed 120,000 lb.

After the trolley was built, it was necessary to install the 85,000-lb unit on the bridge without interfering with production at the blast furnaces. Representatives of Granite City and Dravo, along with the Missouri Boiler and Sheet Iron Co., St. Louis, erection contractors, mapped a program to erect the new trolley with the least delay.

The ore bridge is 380 ft long with a span of 275 ft between the two legs. The trolley tracks are 68 ft-10 in. above the ground. The bridge travels laterally along rails for about one-quarter mile, serving blast furnaces and coke ovens.

It was decided to assemble and wire the main components of the trolley on the ground under the span of the bridge so it would be ready for immediate operation when erected. Because of the odd shape of the trolley unit, timber blocking 20 ft high was built as a ground support. The aluminum-sheathed control house and operators cab are suspended below the trolley frame. After the unit was assembled and tested on the ground with 230-v, d-c, important wiring was disconnected and tagged for easy identification.

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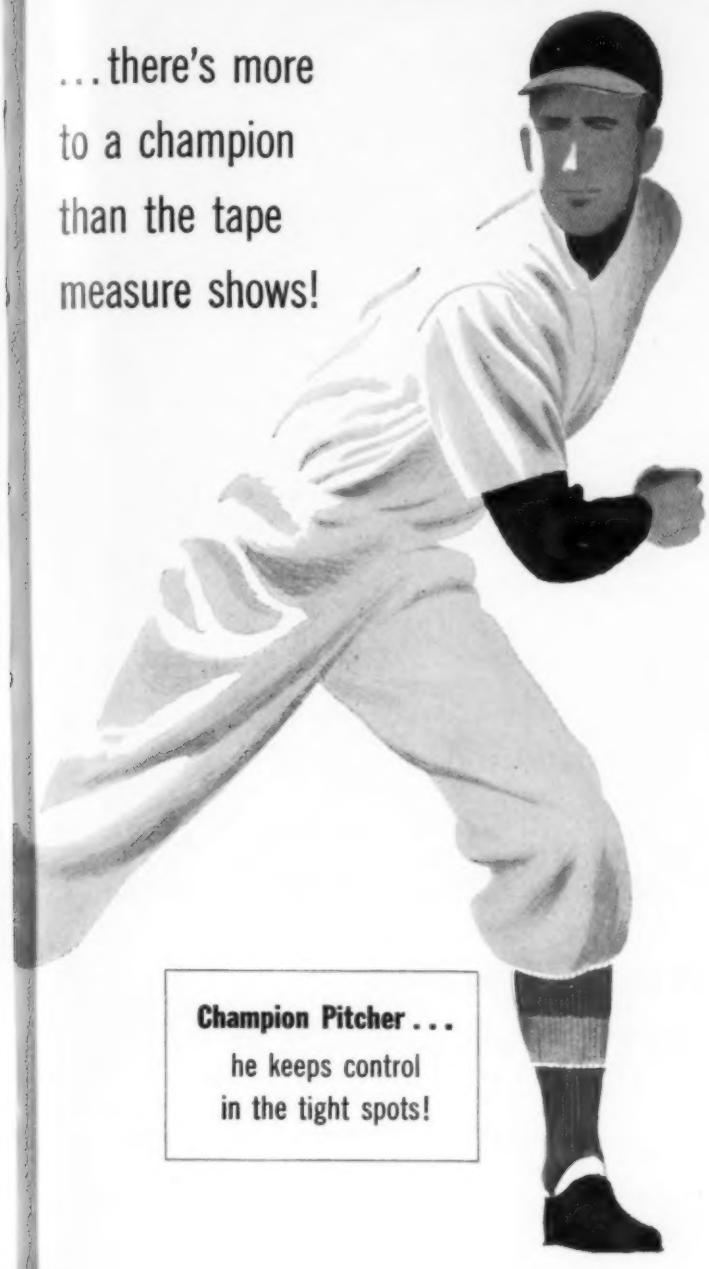
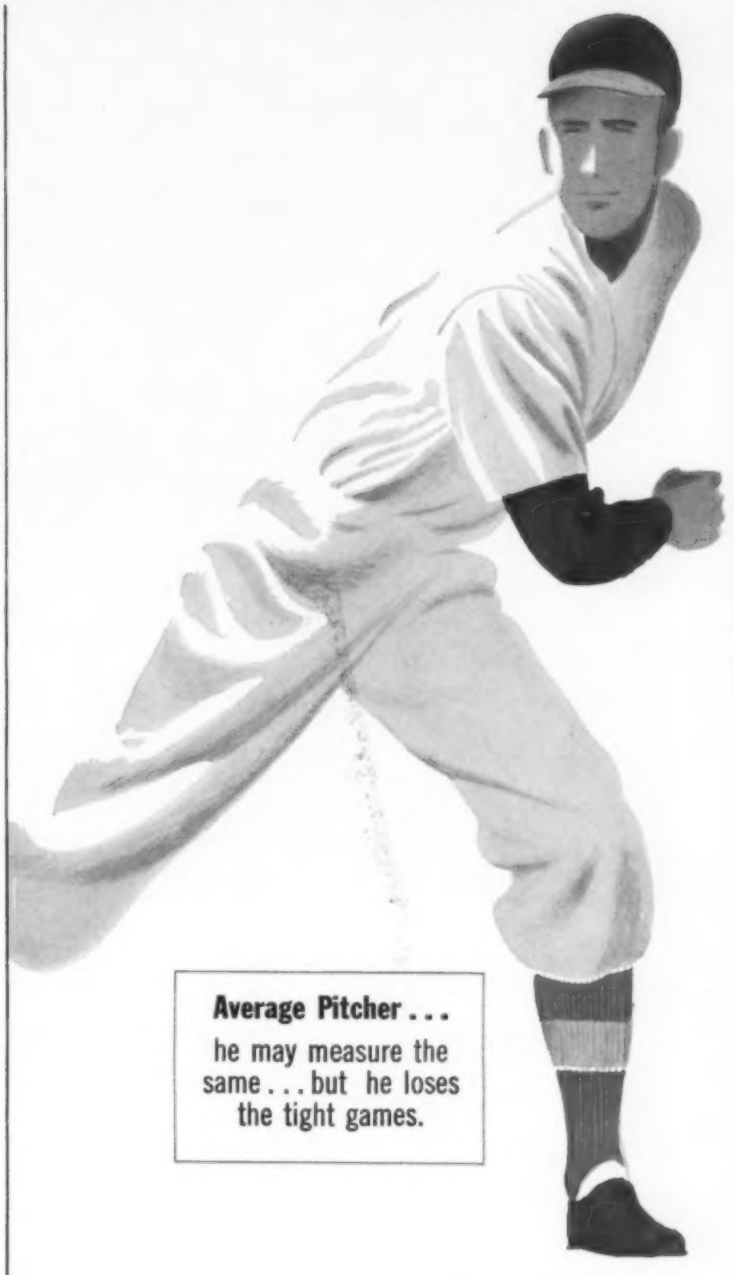


Champion Pitcher . . .
he keeps control in the tight spots!



Average Pitcher . . .
he may measure the same . . . but he loses the tight games.

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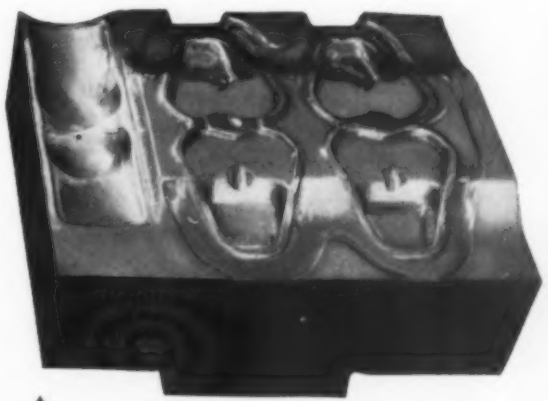

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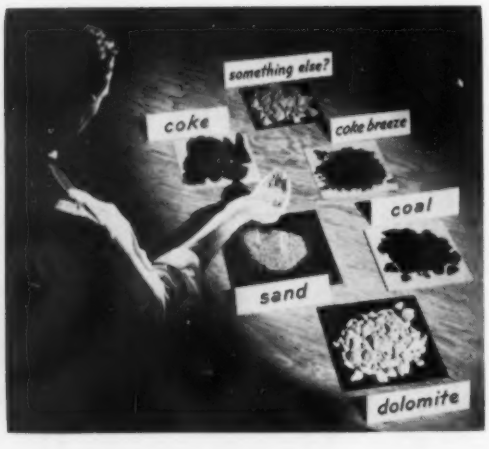

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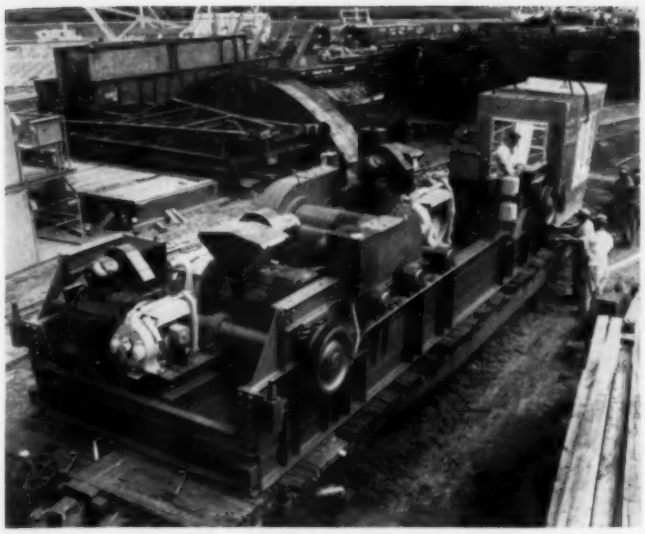


Figure 1 — New lightweight trolley for Granite City Steel Co.'s ore bridge is loaded on a flatcar. Prefabricated operator's cab and control house were shipped along with trolley. Careful plans were made for speedy erection of the trolley at Granite City.

Figure 2 — Air-driven winches were mounted on I-beams straddling the framework of the bridge 10 ft above the trolley rails. Steel cables run down from the winches to the ground.

The day before erection of the new trolley, the old one was used to load all stock bins to capacity. Then, at 7 a.m., on January 22, a crew of 20 men began the erection job.

Two 12-in. I-beams were placed on the bridge framework about 10 ft above the trolley tracks. Two air-operated winches, each with a four part ⅜-in. steel cable, were located at one end of the temporary platform directly above the front axle and drive mechanism of the trolley some 78 ft below. By 10 a.m., the front axle had been unbolted from the frame and hoisted to the rails. The winches then were moved back directly above the rear axle and drive. It was hoisted to the rails by 1 p.m.

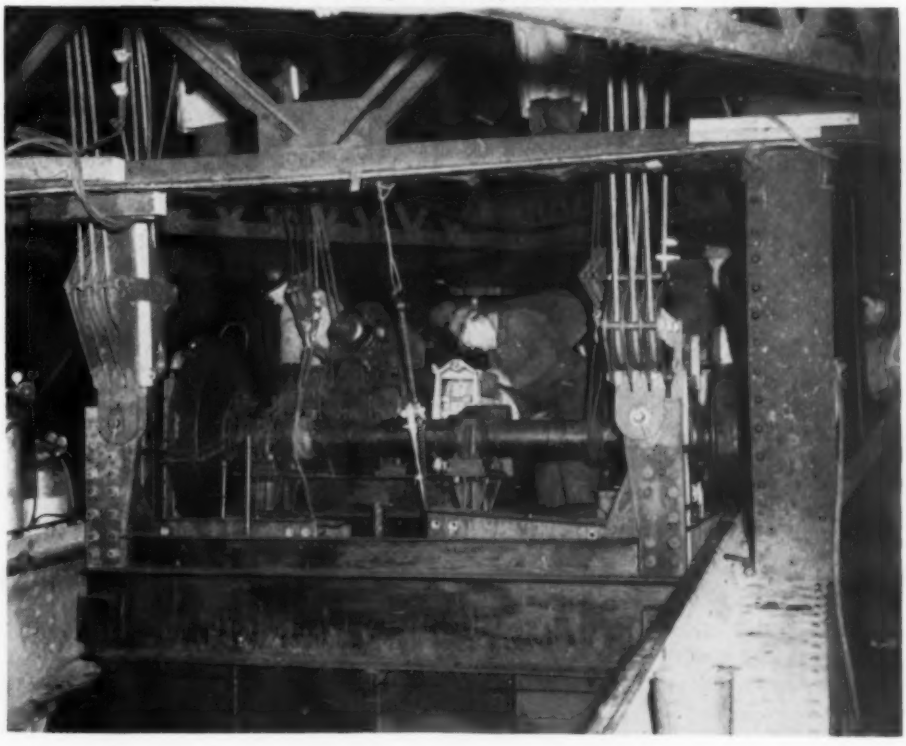
To hoist the trolley frame proper, heaviest component of the assembly, four 15-ton hand winches were mounted on the I-beam platform. Small air motors, ordinarily used for drilling, were connected to the winches, each of which were reeved with six parts of ¾-in. cable. Compressed air at 110 psi was supplied to the motors from a portable, gasoline-driven compressor on the ground. The hand winches were geared low and it took about four hours to raise the trolley frame, with its integral control house and operators cab, 60 ft to the rails.

Once the frame was up, it had to be centered on the axle bearings and bolted into place before the hoisting equipment could be removed. Meantime, electricians and millwrights were connecting motors, installing collector shoes, checking oil and grease points and performing other miscellaneous jobs.

At 3 a.m., the 12-ton bucket was reeved to the new unit and the trolley began moving ore to the furnace stock bins. Three hours earlier it had been necessary to shut down the blower supplying air to one of the two blast furnaces due to lack of raw materials. There were no serious consequences, however. The entire erection job required only 20 hours.

The new four-wheel trolley carries two drum hoists to handle the four in-line reeved bucket. One-inch wire rope is used on the bucket hoists. Each motor is equipped with a small blower to provide filtered air that increases thermal capacity. Drum brakes are the magnetic type rated at 6000 lb-ft. A 45-hp motor drives each axle. These motors also have blowers for filtered air. Control of the trolley travel motors is by full magnetic reversing plugging equipment.

Figure 3 — Trolley frame was attached to the axles while the heavy steel cables at the four corners held it up. Important wiring between axles and control house had previously been disconnected and tagged so it was not long until the new trolley was in operation.

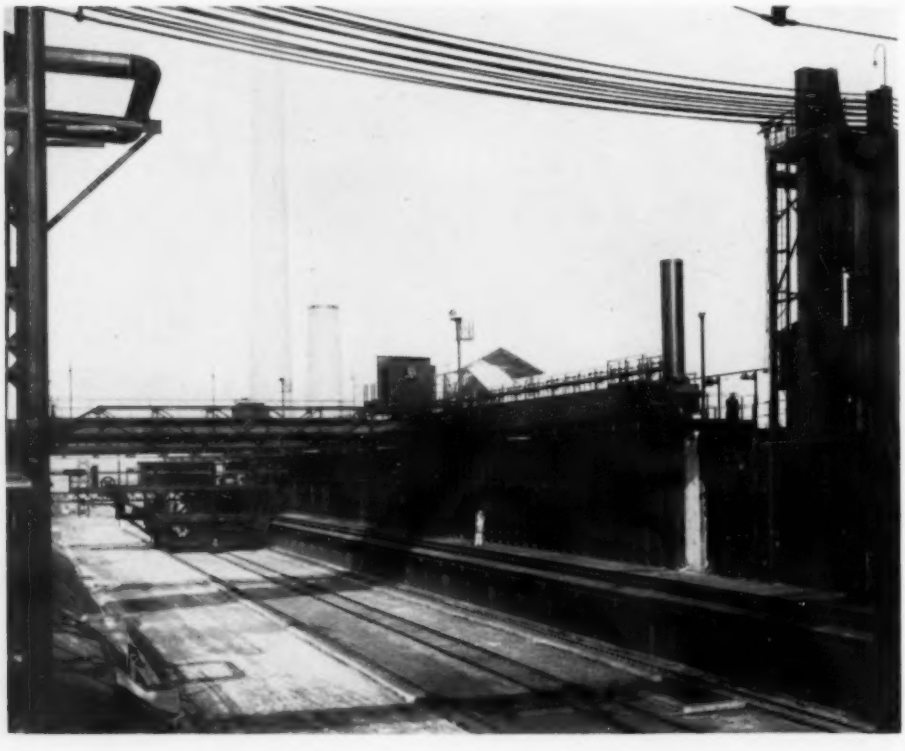


BETHLEHEM STEEL EXPANDS BETHLEHEM PLANT

▲ INGOT producing capacity of the Bethlehem plant of Bethlehem Steel Co. will go up about 15 per cent, according to S. J. Cort, vice president of operations of the company. This increase will come through a greater supply of hot metal from new blast furnaces and through improved fuel conditions in the open hearth.

Mr. Cort said that the program of enlargement, modernization and rebuilding at Saucon Division will provide a 50 per cent increase in the capacity of the structural mills there, with primary emphasis on wide-flange beams pointing toward a target of 60,000 tons per month.

Figure 1 — The new coke oven battery at Bethlehem Steel Co.'s Bethlehem plant consists of 80 ovens and will produce about 1400 tons of coke per day.



As one step in the overall expansion, Bethlehem recently started a new battery of coke ovens which will add 1300 tons per day to the output from the four existing batteries, increasing the plant's annual coke production to around 2,300,000 tons.

Of the most modern design and embodying the latest devices for efficiency of production and control, the new coke ovens are equipped with all appurtenant facilities, such as coke handling, quenching tower and car, by-products plant, etc. Containing 80 ovens, the new battery will, at peak operation, increase the total pushing to 645 ovens per day, an increase of approximately 117 ovens over the number formerly pushed.

Of the horizontal flue type, the new ovens are each 39 ft 2 in. long and 12 ft 6 in. high, inside, taking a coal charge of 15.2 tons. Average on the other batteries is 12.01 tons. Coke production of No. 5 battery will be 11.05 tons; on the older ovens the average for the four batteries is 8.81 tons.

Bethlehem's coke division will use 8250 tons of coal (approximately 165 cars) daily to produce the expected 6300 tons of coke.

To handle the increased amount of gas and coal chemicals, a complete

Beam mill idler rolls stay free-running on TIMKEN® bearings

THIS wide flange beam mill, in operation at a large eastern steel plant rolls beams ranging from 5″ to 36″ deep, with flanges from 4″ to 16″ wide, and weighing 8½ to 426 pounds a lineal foot.

The vertical rolls that work on the outside of the flanges are idlers. To keep them free-running, they were mounted on Timken® tapered roller bearings.

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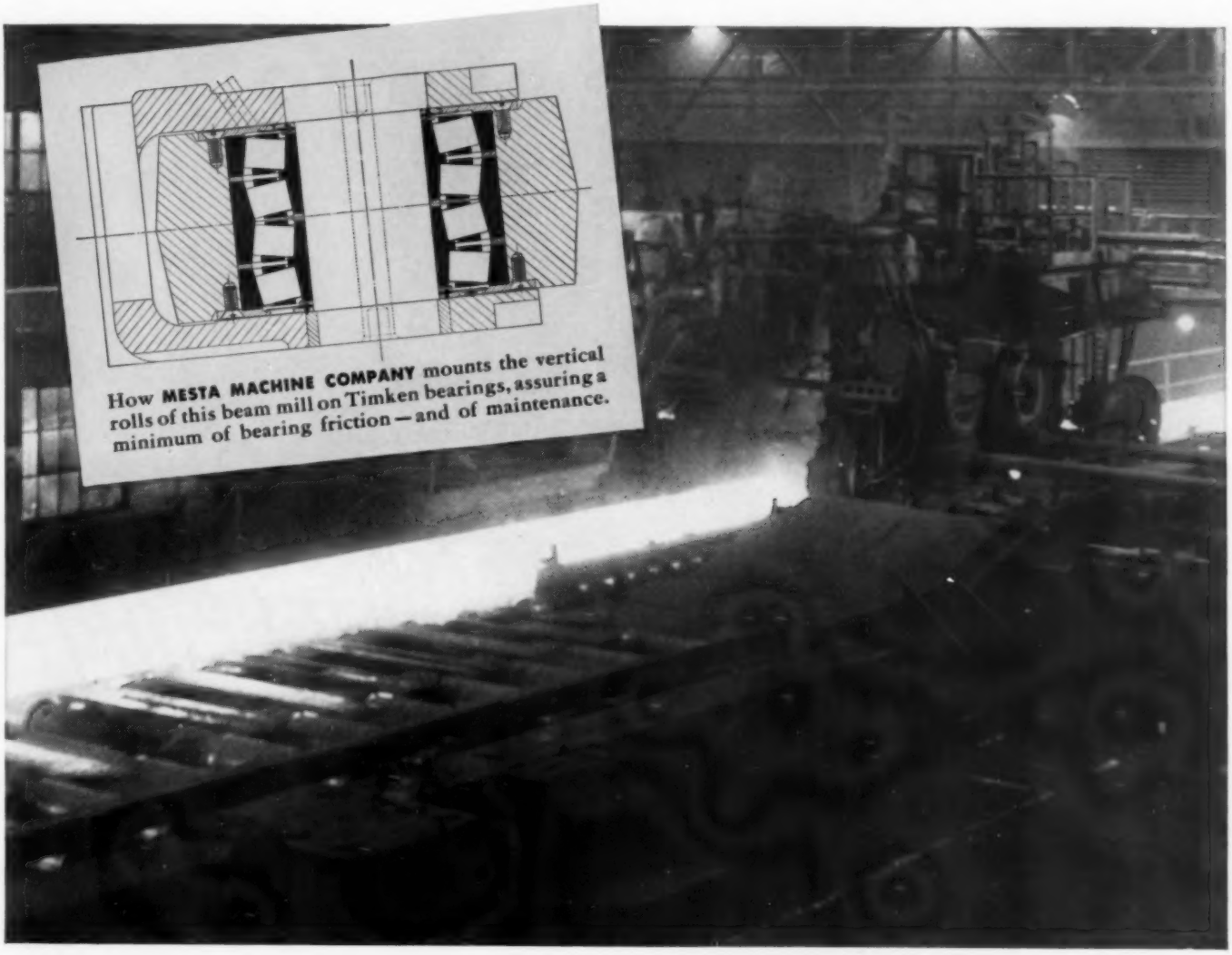

How **MESTA MACHINE COMPANY** mounts the vertical rolls of this beam mill on Timken bearings, assuring a minimum of bearing friction—and of maintenance.

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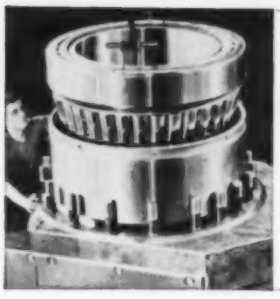
TAPERED ROLLER BEARINGS



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BUILT BY MORGAN Engineering

Illustrated is a 350-ton, 4-girder, 24-wheel Ladle Crane bridge with six individual motor drives.

The six motors are carried on the individual trucks, each motor being coupled to a worm reduction unit on the drive axle. With this type of drive, the usual squaring shafts are eliminated.

On account of the moving mass to be controlled, which would require the usual hydraulic brake for each drive, an air braking system is provided.

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new gas conditioning and coal chemical plant, representing a 25 per cent increase in total equipment, has been constructed as an adjunct to the new coke oven battery. There are also a new boiler house, coke wharf, conveyor, screening plant, quenching tower and car, car handling trackage, motive power, etc. In fact, the battery with all its appurtenances comprises a complete coking and coal chemical unit that could be operated independently if so desired.

Coke oven gas is consumed in the operation of the coke ovens, with the surplus going to open hearth furnaces and reheating furnaces, and for domestic fuel in the city of Bethlehem.

Coal chemical processing equipment installed includes primary cooler, centrifugal exhauster pump to pull the gas off the ovens, electric precipitators to clean gas of tar particles, saturator to remove ammonium sulphate, final cooler, benzol scrubber to remove hydrocarbons, a light oil still, continuous benzol refining facilities, naphthalene recovery plant, and gas desulphurizing unit.

Output of coal chemicals will also be increased with the new ovens in full operation. Daily coal tar production will rise to 57,750 gal, ammonium sulphate to 75 tons, light oil to 24,750 gal, benzol to 17,325 gal, toluol to 2800 gal, xylol to 1000 gal and naphthalene to 3300 gal.

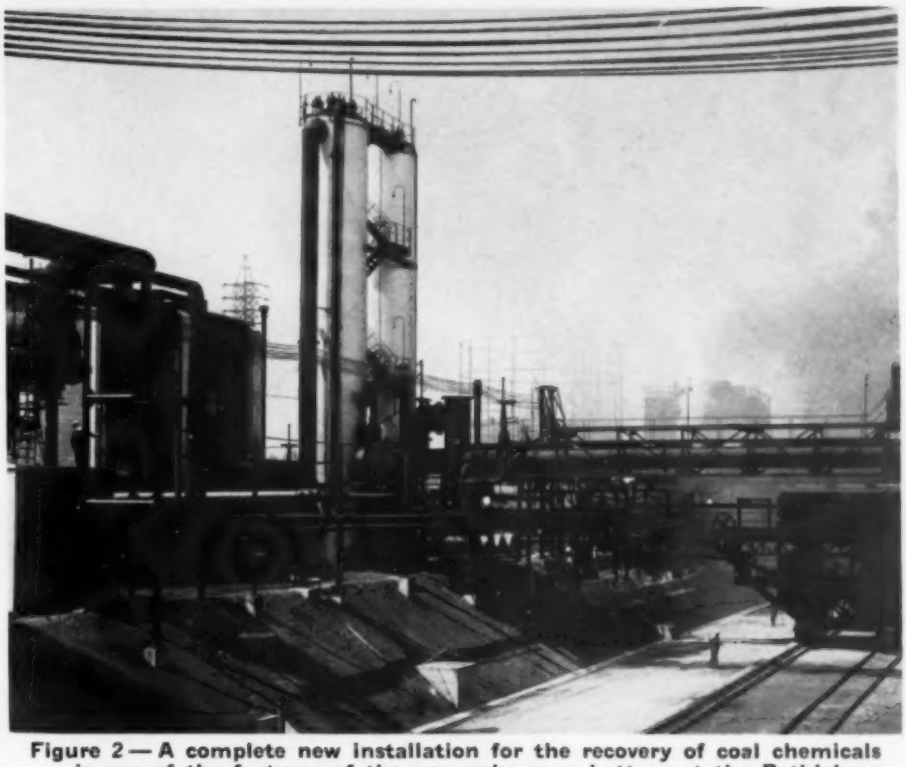


Figure 2 — A complete new installation for the recovery of coal chemicals is one of the features of the new coke oven battery at the Bethlehem plant of Bethlehem Steel Co.

GREEN RIVER STEEL STARTS OPERATION IN KENTUCKY

▲NEARING completion in Western Kentucky is a new steel plant for the production of quality carbon and alloy steels. The Green River Steel Corp. was organized in 1950 by Robert B. Hensley, Frank A. Logan, and Sidney D. Williams who is president of the company. The Defense Production Administration issued a certificate of necessity for the new plant late in 1950. Financing was provided by the sale on public offering of 10-year debentures and common stock and loans made by the RFC and the NPA.

The site selected for the Green River Steel Corp. plant consists of a 127-acre plot three miles east of Owensboro, the county seat of Daviess County, Kentucky. Bounding the site to the northeast is the Ohio River, while the main line of the Louisville and Nashville Railroad adjoins the site to the southeast. Federal Highway No. 60 passes through a corner of the plant site. This strategic location is near the hub of the inland river system, providing barge transportation for raw materials and finished products, and is readily accessible to rail and truck transport. The tract is flat and is above all time flood levels.

A wide range of products is planned by the company. Particular emphasis is being placed on quality killed carbon steels of all analyses and alloy steel of all analyses, including aircraft, gun, armor-piercing shot and bearing quality steels, and stainless and heat resisting steels. The company's facilities are also excellently suited for production of commercial carbon steels of all analyses. Among the products are pressed blooms and billets in sizes 6 x 6 in. to 15 x 15 in., rolled billets from 2½ x 2½ in. to 11 x 11 in. bars (rounds and squares) from 2 to 8⅝ in. and flats 1 to 3 in. thick x 4 to 11 in. wide. The plant has sufficient flexibility for increasing the range of products. Annual ingot pro-

Figure 1 — The plant of the Green River Steel Corp. at Owensboro is unusual. Its initial operation on July 8 is an answer to those who did not think that a new company would be able to overcome the many difficult obstacles in setting up and putting a complete new steel plant into production.

duction of 200,000 net tons is anticipated.

PLANT

The plant consists of four buildings located adjacently to form a right angle "L." The melting furnace building, pouring and teeming building, and ingot heating and processing building form the base of the "L," which is situated nearest to the railroad and highway. The rolling mill building forms the leg of the "L" and extends toward the river. Functional flow of materials and work processes has been of paramount consideration in the plant layout. Building construction is of the mill type, utilizing structural steel framing, roof trusses, and galvanized roofing and siding.

The melting furnace building and the pouring and teeming building consist of two bays, each 80 ft wide. The length of the former is 175 ft, while that of the latter is 250 ft. Clear height to the lower chord of the trusses is 57 ft, providing adequate clearances above equipment for operation of cranes. Total enclosed area of the melting furnace and pouring and teeming buildings is 34,000 sq ft. The exterior bay is the charging floor side of the furnaces. Two top-charged electric furnaces with 17-ft shell diameters are located here. Each operates at a maximum power consumption of 18,000 kva and has a rated capacity of 50 tons. Also in this bay are storage bins for limestone and other fluxing materials, alloying materials, and furnace repair refractory materials. A 200-ft open extension of this bay forms the scrap yard where scrap steel, which is the principal raw material of the process, is unloaded and stored prior to its use as charge for the furnaces. The interior bay has facilities for tapping the electric furnaces at the completion of a heat and for teeming and stripping the ingots.

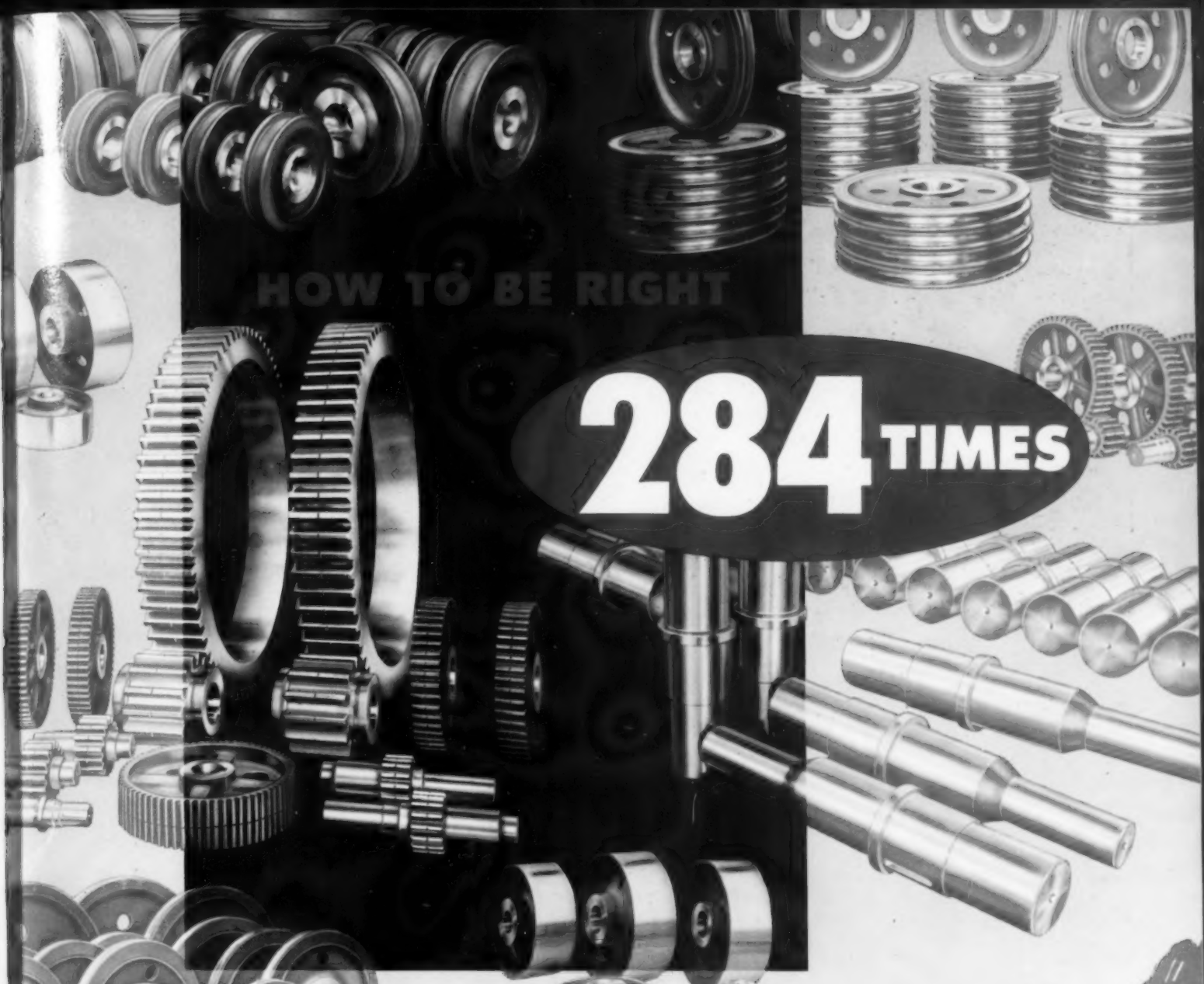
The ingot heating and processing building consists of a single bay 80 ft wide and 210 ft long. Clear height to the lower chord of the roof trusses is also 57 ft. Total enclosed area is 17,000 sq ft. Located in this building are eight soaking pits in which ingots are heated to proper processing temperature. Fuel for the soaking pits is either natural gas or oil. After heating in the soaking pits, the hot ingots are transferred to two forging presses. The Dornin process is used to separate the sound steel of the ingot from the segregate containing impurities. The presses are 2,500 and 1,500 tons.

The rolling mill building has a single, 80-ft wide bay which is 835 ft in length. An extension to this bay 40 ft wide and 455 ft long houses a change area, a motor and control room, and a shop. Clear height to the underside of the roof trusses is 42 ft, providing adequate clearance for cranes. Enclosed area of the rolling mill building is 85,000 sq ft. The major mill equipment consists of three stands. All stands have rolls 24 in. in diameter and 60 in. long. The No. 1 stand is a two-high reversing stand driven by a 2100 hp, d-c reversing motor. The No. 2 stand is a three-high intermediate stand driven by a 1250 hp, a-c motor. This motor also drives the No. 3 stand, which is a two-high finishing stand. These mills produce blooms from 6 to 12 in. billets, from 2 to 6 in. rounds from 2¼ to 8⅝ in. in diameter, and flats and special sections. In the area adjacent to the rolling mill equipment are located a reheating furnace, slow cooling pits, straightening machine, pickling vats, and miscellaneous appurtenant equipment. A forging hammer is located in a lean-to adjacent to the building.

The general offices of Green River Steel Corp. are housed in a remodeled two-story brick residence existing on the site. Water for operations is supplied from six 700 gpm wells located on the site. Natural gas is supplied by the Western Kentucky Gas Co. through the facilities of Texas Gas Transmission Corp. Power is supplied by Kentucky Utilities at 138 kv through a new 33-mile line to the plant from its Green River station at South Carrolton, Ky. An emergency tie with Owensboro Municipal Utilities facilities is maintained.

CONSTRUCTION

The construction of the plant was supervised by Ebasco Services, Inc., acting as an agent for Green River Steel Corp. The general contractor for construction was Globe Erection Co., Louisville, Ky. Patterson-Emerson-Comstock of Pittsburgh, Pa., was the electrical contractor on the project. Other contractors or subs included: Lombard Corp. for building foundations, Voigt-Conant for steel erection, Olson Engineering Co. for soaking pits, Amsler-Morton for annealing furnaces, Nukem Products for pickling tanks, Raymond Concrete Pile Co. for cast-in-place piling, and O. L. Depp for grading.



A large mid-west steel company with a reputation for making right decisions installed 284 Tool Steel Process parts on two new ladle cranes.

Substantial operating-maintenance savings previously experienced with Tool Steel Process parts was their reason. They found as others have, for extra long life, Tool Steel Process hardened parts are unequalled. On the two cranes the company specified:

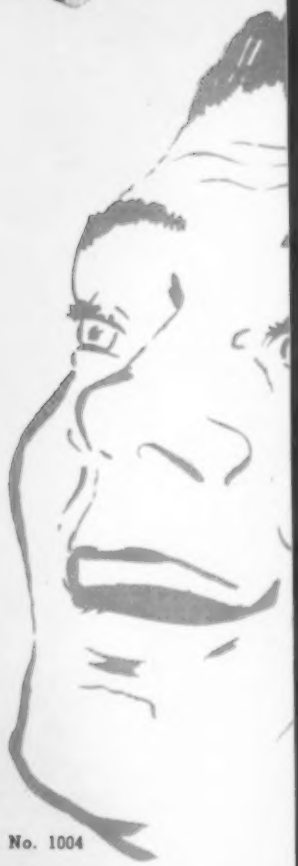
32 AXLES • 60 GEARS - PINIONS • 192 WHEELS (sheave, track, brake)

TSP ... products are hardened by our special process. The file hard surface to the full depth of permissible wear gives maximum wear. The core, refined for toughness and ductility, gives maximum strength.

You receive an absolutely positive written guarantee that TSP products will give a longer life in the same service than any other product.

THE TOOL STEEL GEAR AND PINION CO.
CINCINNATI 16, OHIO, U.S.A.

Write today for Bulletin 252.



Ad No. 1004

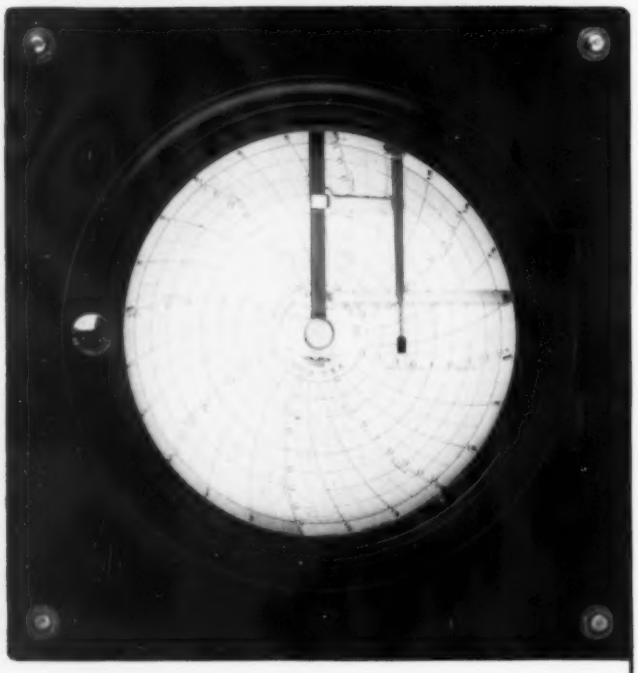
The Standard of Quality Since 1909 for Gears • Pinions • Rolls • Wheels and Other Hardened Products

accurate— sensitive— trouble-free— easy to service—

Four reasons for choosing these Republic Low Pressure Instruments to measure flow or pressure of gas and air

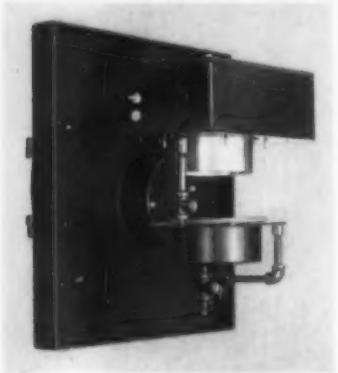
in

OPEN HEARTH FURNACES
SOAKING PITS
REHEATING FURNACES
COKE OVENS
SMELTING FURNACES

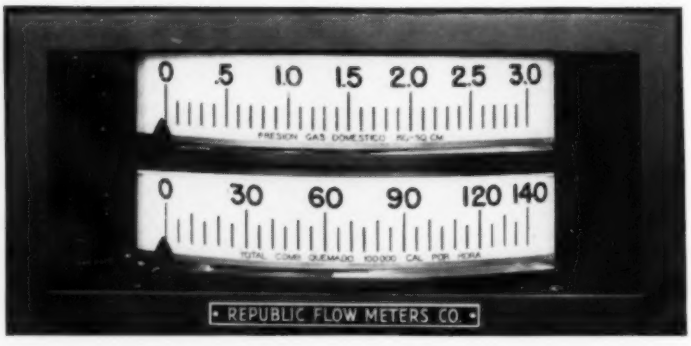


Republic Oil Sealed Bell Recorder at left responds to the slightest changes in furnace pressure and stack draft, and works independently of other controls. Operating principle is so simple that a minimum of maintenance is required. Sealed bell withstands high temperatures and will not crack, rupture or wear out. For pressure or vacuum measurement, the Recorder may be connected directly to a furnace or pipe line. For differentials, it may be connected across an orifice.

Recorder has ranges 0-0.2″ H_2O and 0-8″ H_2O at static pressures to 10 psi. On low range, large 4″ diameter bell gives sensitivity of ±.001″ H_2O.



For quick periodic inspection and cleaning, mineral oil reservoir at rear of Recorder may be lowered by disconnecting one pressure connection and four bolts. Calibration is not changed.



Horizontal Indicator is operated by a tough, resistant diaphragm made of polythylene plastic. Each Indicator is separate and may be individually removed or adjusted. Indicator arm swings on jeweled bearings for friction-free accuracy. Internally illuminated scales may show pressure, draft, pressure-draft combination or differential pressure. Ranges from 0-0.2″ H_2O to 0-40″ H_2O.

Two Indicators are often mounted together to read air flow—gas flow ratio in furnace firing. They may be calibrated so their pointers line up when air and gas are in the correct ratio.

Both instruments fully described in Bulletin 802. Write for your copy today.

REPUBLIC FLOW METERS CO.
2240 Diversey Parkway, Chicago 47, Illinois

ELLIOTT 1000-hp dc motor helps increase capacity of skelp mill

The two additional mill stands and edging rolls driven by Elliott motors were part of a modernization program which increased the mill capacity approximately 20 per cent. The improvements including installation of the new motors were completed in record time.

This Elliott mill type motor rated at 1000-hp, 400/800 rpm, 600 volts, d-c, powers the production-boosting modernization of a skelp mill. This motor drives the two additional roughing stands made necessary by the use of heavier slabs.

A new edging stand, located after the roughing stands, is powered by an Elliott Crocker-Wheeler 200-hp, 420/1050 rpm, mill type motor.

For details on this and other Elliott large motors, consult your local Elliott representative or write to Elliott Company, Ridgway Division, Ridgway, Pa.

Elliott FABRI-STEEL MOTORS AND GENERATORS

R3-27

ELLIOTT Company

RIDGWAY DIVISION

FOR MOTORS 1-200 HP: CROCKER WHEELER DIV. AMPERE, N. J.

HOW HIGH STACKING AFFECTS FORK TRUCK STABILITY

By HAROLD MILZ
Chief Engineer
Mercury Manufacturing Co.
Chicago, Illinois

▲ The present high cost, and in some cases the impossibility, of building new or additional storage facilities has re-emphasized the desirability of stacking materials in storage as high as is practical and safe. It is becoming increasingly important that every commercial warehouse and in-plant storage materials handling engineer, "utilize the cube" to the best possible advantage.

This urgency has resulted, upon occasion, in the placing of a premium on the stacking heights of fork trucks without due regard to the hazards and limitations involved. For safety and efficiency, every user ought to understand these physical laws, governing fork truck stability.

It is general practice to leave the problems of fork truck stability to the manufacturer of the truck. Generally, the conditions of operation are outlined and a truck is designated that will do the job. This is sound practice and works out well—if the original job specifications are complete and are accurately determined and transmitted. Many times overlooked is the fact that lighter loads can cause stability trouble if those loads are longer than anticipated, or if they are odd shapes and their centers of gravity fall too far forward. It is also true that heavier loads may put undue strain upon tires, brakes, wheel bearings and the hydraulic system.

It is, therefore, extremely important for the truck purchaser to understand the factors that affect truck stability; to be familiar with the formulas involved; and to be able to apply them to his everyday materials handling problems.

FORK TRUCK STABILITY

A fork truck carries loads ahead of wheels in cantilever fashion. Therefore, the downward force is in front of, not over, the points of support. The fork truck can be considered as a simple lever, Figure 1, with the center of the front drive wheels acting as a fulcrum point between the load and the counterbalancing action of the truck.

Thus, the trailing moment — the truck weight back of the forward wheels, D, multiplied by its lever arm, C — must always be appreciably greater than the forward moment — the load weight, A, multiplied by the length of its lever arm, B. Or C $\times$ D must always exceed A $\times$ B. If it does not, the truck becomes unstable and tips forward.

The principal factor determining the load that can be transported and tiered is the amount of weight remaining on the trailing wheels when the loaded truck is tilted fully forward at the extreme of its lift capacity.

Both electric and gasoline-powered trucks are subject to this same analysis since they are subject to the same forces and conditions. It is a simple matter to assure sufficient weight remaining on the trailing wheels either by increasing the truck wheelbase or by increasing the counterweight, or both. However, wheelbase length is increased only at the expense of maneuverability. Aisle widths do not usually permit unlimited wheelbase extension.

The amount of weight that can be carried on the trail axle is likewise limited. It is limited not by axle

Industrial Cut Gears

Contribute Vitally to the Dependable Operation of this Huge "PAGE" Walking Dragline

Huge—yes! Page Walking Draglines are as big as a five room bungalow with booms of 185 to 200 feet long to swing and hoist buckets up to 16 cu. yd. capacity.

Powered by Page Diesel Engines—Industrial Gears are used in the swing motor assemblies, hoist and load drum bed assemblies and other vital components.

Heavy-duty is a must for all operating parts — break-downs in remote regions of operation must be guarded against.

"I-G" DUROCASE GEARS and "I-G" GEARS in the specifications are basic. Why not put them to work on your equipment.

If you would like to see our plant at work pictorially, write for Bulletin 152-A. Our entire production is devoted exclusively to Gear and Sprocket cutting. We have no side lines.

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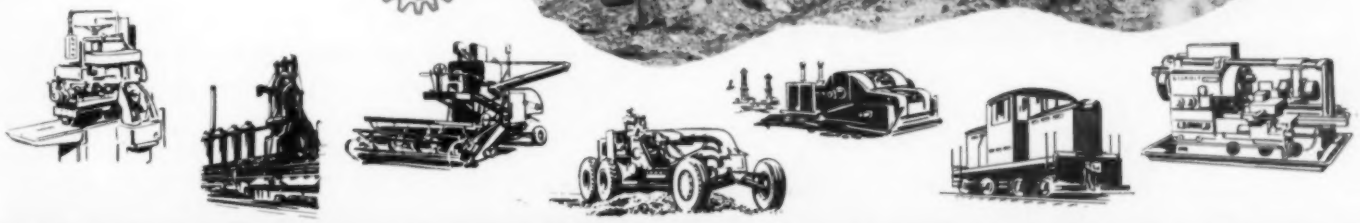

Industrial Gear Mfg. Co.

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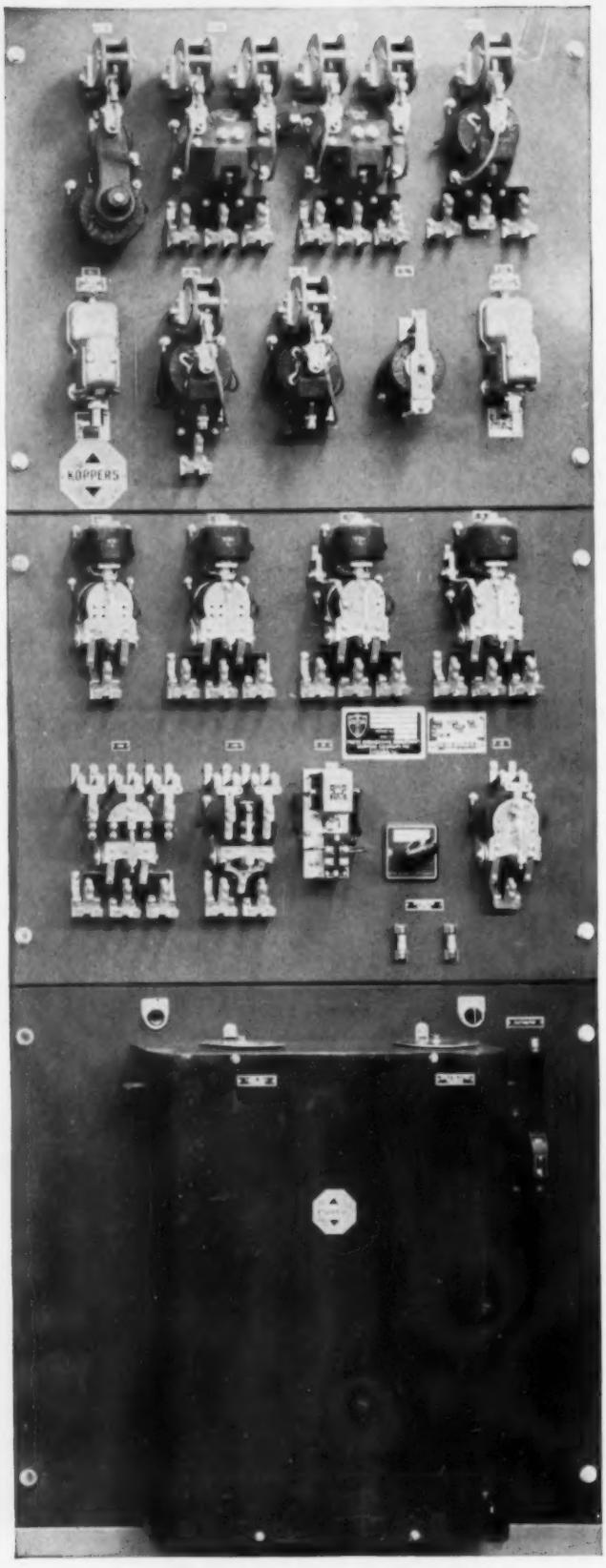

Freyn-Design BLAST FURNACE Reversing Distributor Control

AFFORDS THESE FEATURES:

1. **Coordinated, simultaneous operation of distributor and skip hoist (patented) eliminates the distributor movement as a time factor in charging.**
2. **Dynamic braking affords micrometer stopping, without drift. Shoe brakes not required and not used.**
3. **Change of rotation angle in step with the charging round (patented) eliminates the necessity of load-counting devices.**
4. **Rotation angle change after a selected number of skip loads is an available option.**
5. **Positive interlocking forces completion of distributor rotation before small bell can be opened, safeguarding against improper charging.**
6. **Extreme simplicity, easily understood control, utilizing mill-type motor supplied from constant-voltage source in common with other charging equipment. Maximum reliability.**
7. **No speed-up required to avoid delays at higher rotation angles.**
8. **The recognized standard of the industry for fourteen years, incorporating the accumulated experience of 158 installations.**
9. **Rugged—Maintenance free—Not one Freyn-Design Distributor Control has yet been worn out or replaced.**

"ASK THE MAN WHO OWNS ONE"

KOPPERS

METALLURGICAL PLANT DESIGN AND CONSTRUCTION

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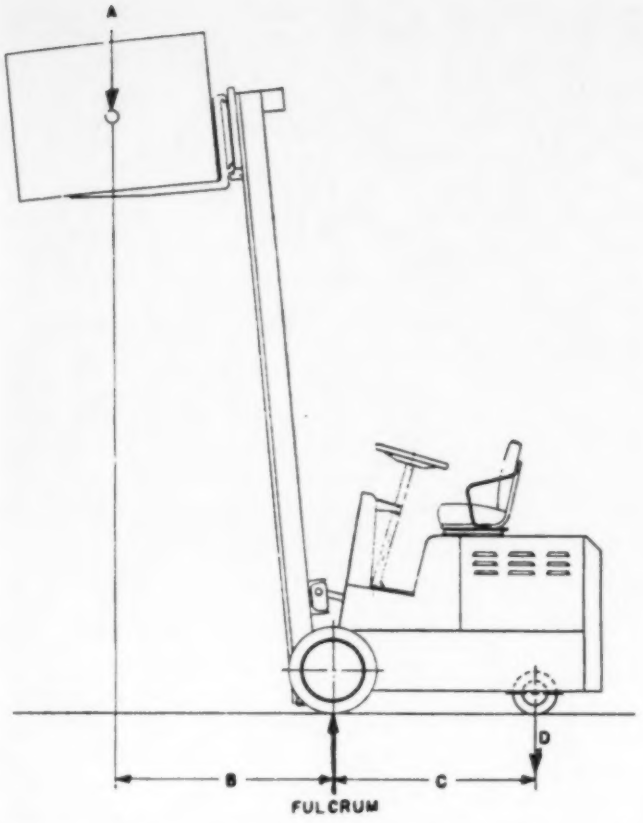


Figure 1 — The truck weight on the back axles times C must be greater than the load weight times B if the truck is not to tip over. (See figure on left.)

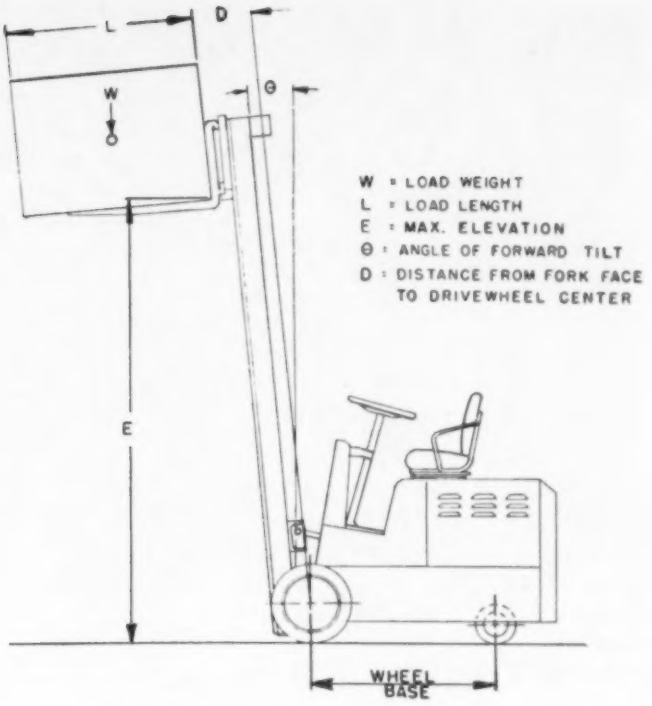


Figure 2 — Nomenclature used for calculating overturning moment. (See above.)

design, but by both the amount of effort and the number of hand turns that we can expect of an operator in steering a truck — unless power-steering devices are used.

The design of trucks, therefore, is governed not only by capacity and wheelbase, but also by steering effort and stability. It is generally accepted that steering becomes too difficult for good operation when the trail wheel weight exceeds 7500 lb.

In order not to exceed this figure, and yet include sufficient weight to permit full forward tilt at extreme elevation (in other words, to determine the *trail wheel weight required* to provide adequate stability under all normal operation conditions) it is necessary first to calculate the *overturning moment.*

CALCULATION OF OVERTURNING MOMENT

An overhanging load on a fork truck creates a forward overturning tendency. The tendency may be calculated by multiplying the load weight by the distance from the fulcrum point, or center of the forward wheels, to the load when elevated and fully tilted forward. Such a product is called the overturning moment, and is expressed in units of inch-pounds (in.-lb).

For convenience in calculation, overturning moment is divided into three parts: (1) load, (2) loss and (3) tilt moments. Added together they produce the overturning moment.

Load moment is the product of the load weight and one half of the load length, measured parallel to forks. Load moment is one of the terms commonly used to define the capacity of a fork truck.

Loss moment is the product of the load weight and the distance from the fork face to the drive wheel center measured with the mast in a vertical position. This dimension is a constant for any one truck model.

Tilt moment is the product of the gross weight of the pay load times the maximum fork elevation times the sine of the forward tilt angle. This value is approximate because the height is measured to the fork level rather than to the vertical center of the load. However, it is accurate enough for all practical purposes.

The load, loss and tilt moments added together produce the total overturning moment. In these calculations, all weights must be in pounds and all dimensions in inches.

With this basic data at hand, let us determine the trail weight necessary on a properly-designed fork truck bearing a nameplate rating of 144,000 in.-lb handling a 6000-lb, 48-in. long load. The truck is assumed to be a standard model lifting to a height of 115 in. with a forward tilt of 5 degrees. The manufacturer's literature specifies a 54-in. wheelbase, with 18-in. from the fork face, or back end of the load, to the drive wheel center.

As previously stated, the overturning moment (O.M.) is expressed as (see Figure 2): O.M. = Load Moment plus Loss Moment plus Tilt Moment, where:

$$\text{Load Moment} = W \times \frac{L}{2}$$

$$\text{Loss Moment} = W \times D$$

$$\text{Tilt Moment} = W \times \sin\theta \times E$$

W = load weight, lb
L = load length, in.
D = distance from fork face to drive wheel center, in.
E = maximum fork elevation, in.
θ = angle of forward tilt, deg.

Calculations are as follows:

$$\text{Load Moment} = W \times \frac{L}{2} = 6000 \text{ lb}$$

$$\times \frac{48 \text{ in.}}{2} = 144{,}000 \text{ in.-lb}$$

Loss Moment = W × D = 6000 lb × 18 in. = 108,000 in. lb

Tilt Moment = W × sine θ × E = 6000 lb × 0.0975 × 115 in. = 60,375 in.-lb

Therefore, the overturning moment, O.M. = 312,375 in.-lb

CALCULATION OF REQUIRED TRAIL WEIGHT

The next step is to calculate the amount of weight subtracted from the trail wheels under these conditions. This is done by dividing the overturning moment by the truck wheelbase. The amount of weight subtracted from the trailing wheels is

$$\text{therefore O.M.} = \frac{312{,}375}{54 \text{ in.}} = 5785 \text{ lb}$$

The questions which naturally follow are: Is this weight adequate for safe operation under all normal conditions? If not, how much additional weight is required?

Up to this point we have been concerned with static stability only. However, actual use of the truck involves movement and this requires consideration of additional dynamic forces. This movement may include bringing the truck to a quick stop when carrying the load at slightly elevated position, or cautious maneuvering as required in the tiering operations. It does not allow for traveling at full speed with the load elevated—a practice prohibited by all safety programs. These additional dynamic forces require additional weight on the trail wheel.

Dynamic forces are more difficult to determine than simple overturning moments. They require a knowledge of the exact location of the combined center of gravity of truck and load as well as the exact rate of deceleration.

However, when stacking is done up to 12 feet—which covers by far the largest percentage of all trucks in use today—a simple empirical formula, which works out well in practice, has been developed to take care of these forces. In those rare cases where higher lifts are involved, additional consideration must be given to the serious problems of stability that are created. When elevating up to 12 ft, the additional trail weight required to offset these forces equals one-tenth of the load weight plus 600 lb. This 600 lb is a constant regardless of load weight. Because this example which we have discussed uses a 600 lb load weight, we will require 1/10 of 6000 lb plus 600 lb or 1200 lb. Adding this figure to our previously-determined figure of 5785 lb, we arrive at a final required trail weight of 6985 lb.

We can now refer to the manufacturer's literature or make inquiry to determine whether the truck contemplated meets the performance requirements. In the example given, the required trail weight falls well within the 7500 lb limit, mentioned earlier as required for easy steering.

HOW TO USE THIS DATA

An understanding of the factors involved in truck stability on the part of the purchaser will serve a dual purpose. First, it will cause him to check for maximum loads and tiering height so that he can provide accurate information to the truck manufacturer in order to obtain the proper truck for the job.

Figure 3 — High stacking increases warehouse capacity.

Secondly, it will enable him to check and compare specifications of competitive trucks so as to be sure not to decide in favor of a somewhat lower cost at the sacrifice of adequate stability.

An analysis of truck stability factors also makes clear the fact that static stability remains constant regardless of how high the load is lifted when the truck is on a level floor and the mast is in a vertical position. Not one inch-pound is added to the overturning moment, nor is one pound subtracted from the trail weight, when loads are lifted straight up. The very slight forward shift in load center due to mast deflection and clearance in the mating mast parts is readily compensated for by tilting the mast.

However, there are certain conditions that throw the mast out of its true vertical position: for example, (1) depression or grade in floor surface, (2) deflection of rear springs, and (3) any "whipping" of the uprights or shifting of the bearings while under load. Obviously these factors, if involved, must also be taken into consideration when computing fork truck stability.

PRACTICAL POINTERS FOR OPERATORS

When you have a heavy load high in the air, think of yourself as a professional juggler. If you could sense the balance of your load just as skillfully as he does, you could probably go three times higher in your stacking than anybody else. Now how can these principles be applied?

First never tilt the mast forward when carrying a load in the elevated position. The point of support must be kept under the load for stability.

Second, never tilt the mast backwards beyond the maximum angle of tilt. Doing this allows the center of gravity to go too far toward the rear, and you lose side stability.

The right compromise is to tilt backward the distance of a foot or so, or at least far enough backwards so that the deflection of tires, springs, uprights, and other parts of the machine will not allow the back edge of the load to be farther forward than the front face of the drive tires. The juggler's idea is still in force here. You have to keep the load over the point of principal support, the front wheels.

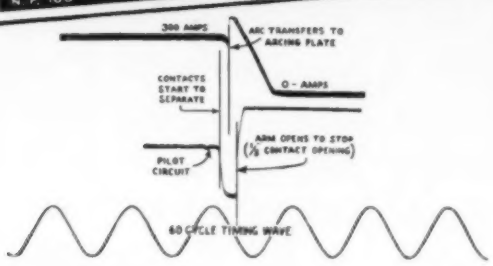
Avoid making a steering turn with the load in the full elevated position. If you do not, the truck is liable to turn over sideways. If possible make your turns in the aisle with the load at intermediate height.

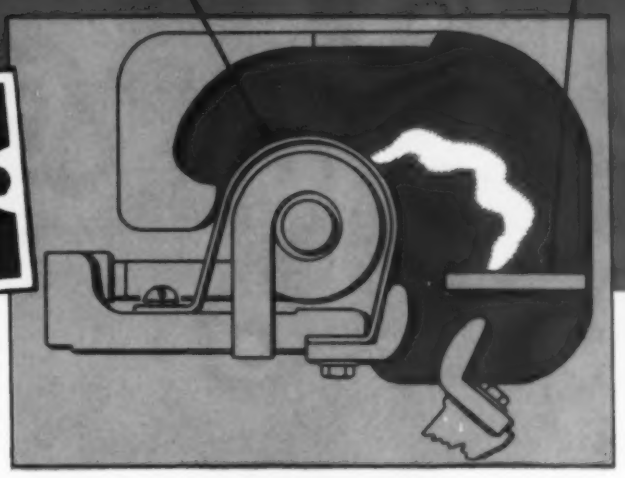
Last, do not accelerate too fast or slam on the brakes too quick when the load is high. Either operation, may cause the truck to overturn. Whenever possible, avoid carrying loads at elevated heights.

Quick Arc Transfer

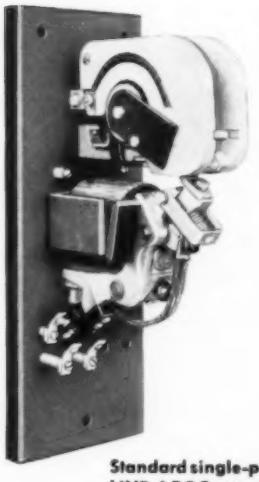
from tips to blowout guard and arcing plate in 1/500th second

WITH EC&M
LINE-ARC
(TRADE MARK REG.)
CONTACTORS
N. P. 168





As the contacts start to separate, the arc is removed in 1/500th second. The oscillogram at the left shows this clearly.



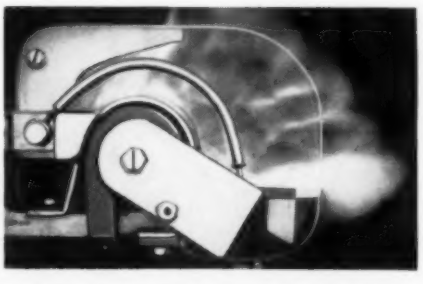
Standard single-pole LINE-ARC Contactor.

Keeps Contacts COOL for LONG Life

In EC&M LINE-ARC Contactors, the arc leaves the contacts quickly . . . and keeps moving in a line, centered between but not touching the arc shields. One end of the arc travels along the arcing-plate and the other end along the circular guard over the blowout coil.

In repetitive operation, the copper contacts remain cool. This low operating temperature keeps the copper hard and greatly extends the life of the tips.

EC&M LINE-ARC Contactors have a reputation for high performance. Ask our nearby office to explain the advantages of these popular contactor controllers for cranes, mill drives and material handling machines



100-ampere contactor with special glass arc shields ruptures 300-ampere load. This convincing demonstration has been witnessed by hundreds of visitors at the EC&M Factory.

No Destructive Arc Shield Burning

An a-c bucket crane has handled over one million tons of fertilizer with minimum upkeep on EC&M LINE-ARC Contactor Control. In seven years, three arc shields were accidentally broken, but none have been replaced due to burning. Contacts on one size contactor have been replaced on an average of once a year, the next size every two to three years, and no replacements on the largest size. It pays to specify EC&M Control.

SEND FOR BULLETIN 1145

THE ELECTRIC CONTROLLER & MFG. CO.
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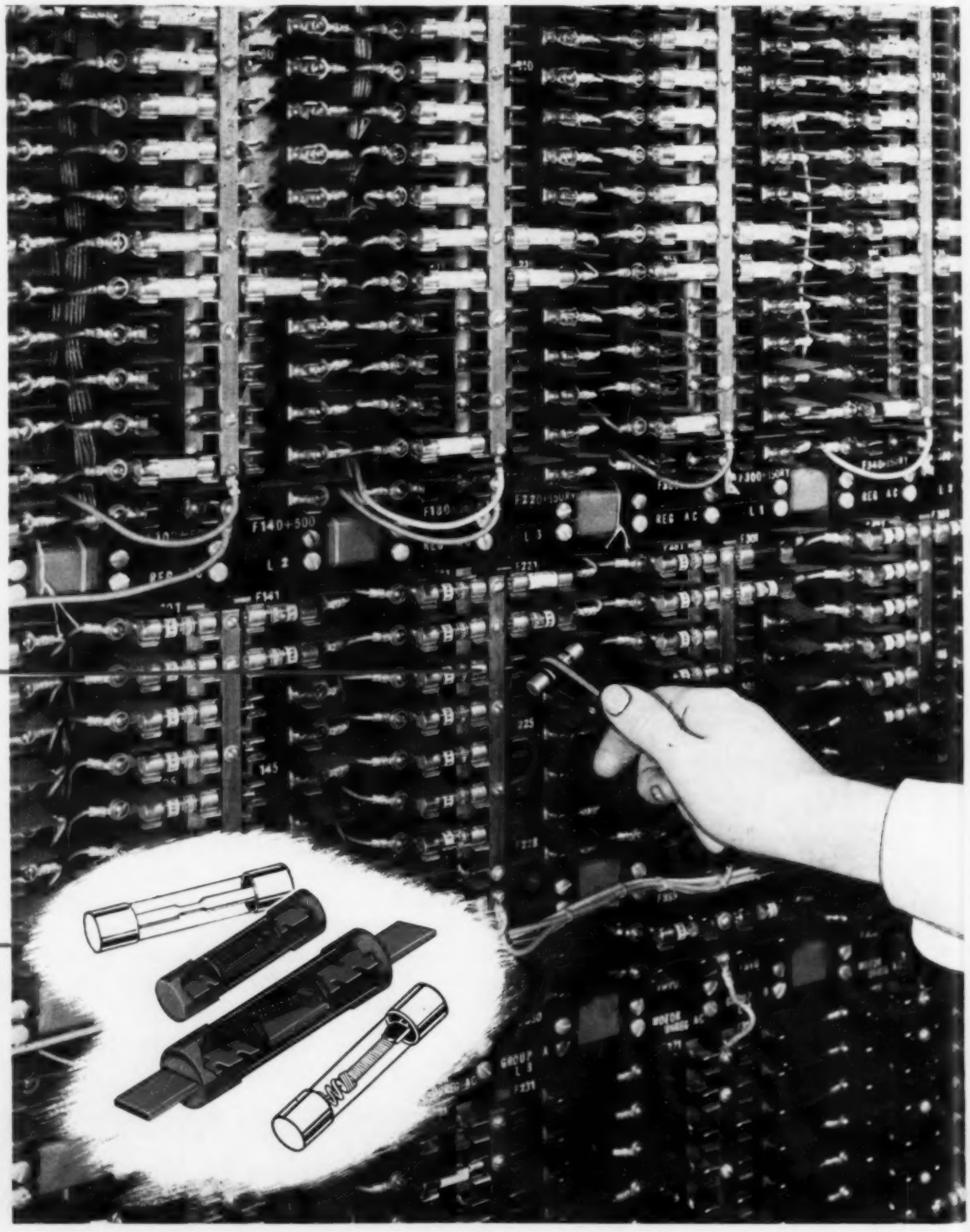
More Than 400 FUSETRON and BUSS Fuses are used in IBM's Electronic Data Processing Machines



The new IBM electronic data processing machines, made up of eleven units, can multiply or divide more than 2,000 times a second, and add or subtract more than 16,000 times a second.

In these electronic data processing machines, protection of the intricate wiring is of the utmost importance. IBM uses between 400 and 500 FUSETRON and BUSS fuses in each of its new '701' high speed calculators.

On circuits where surge currents might cause an ordinary fuse to blow needlessly, IBM specifies FUSETRON dual-element fuses because of their long time-lag. On other circuits where no surges occur, or where even a short-lived surge might cause damage, single-element BUSS indicating fuses are used for fast opening in case a fault occurs.

When this newest and most powerful high speed electronic calculator was displayed at IBM World Headquarters on March 27th of this year, FUSETRON and BUSS fuses were one of the component parts that made the operation of this spectacular machine possible.

You Can Have The Same BUSS Dependability and Accuracy in Your Plant . . .

FUSETRON dual-element fuses for the protection of industrial and commercial circuits are made with the same precision demanded for this ultra-modern IBM equipment. That's why FUSETRON fuses, used throughout the entire electrical system give you a degree of protection obtained with no other device.

And, don't forget — FUSETRON fuses not only give you protection against short-circuits, they give 10 point protection: 1. Protect against short-circuits. 2. Protect against needless blows caused by harmless overloads. 3. Protect against needless blows caused by excessive heating — lesser resistance results in much cooler operation. 4. Provide thermal protection — for panels and switches against damage from heating due to poor contact. 5. Protect motors against burnout from overloading. 6. Protect motors against burnout due to single phasing. 7. Give double burnout protection to large motors — without extra cost. 8. Make protection of small motors simple and inexpensive. 9. Protect against waste of space and money — permit use of proper size switches and panels. 10. Protect coils, transformers and solenoids against burnout.

FUSETRON
TRUSTWORTHY NAMES IN ELECTRICAL PROTECTION
BUSS

Start Saving With Fusetron Fuses

FOR MORE INFORMATION use this coupon

BUSSMANN MFG. CO.
University at Jefferson, St. Louis 7, Mo.
(Division of McGraw Electric Co.)

Please send me complete facts about FUSETRON dual-element fuses.

Name .....
Title .....
Company .....
Address .....
City ..... State .....

953

*FUSETRON is a trade mark of the Bussmann Mfg. Co., Division of McGraw Electric Co.

Two important parts of

UNIONMELT WELDING

Trade-Mark

You Can't See

This is UNIONMELT welding—instantly recognized by the special granulated material you see blanketing the weld. *You can't see* the powerful electric arc that fuses the metal beneath at the highest production rate attainable. No sparks or glare disrupt nearby plant activity.

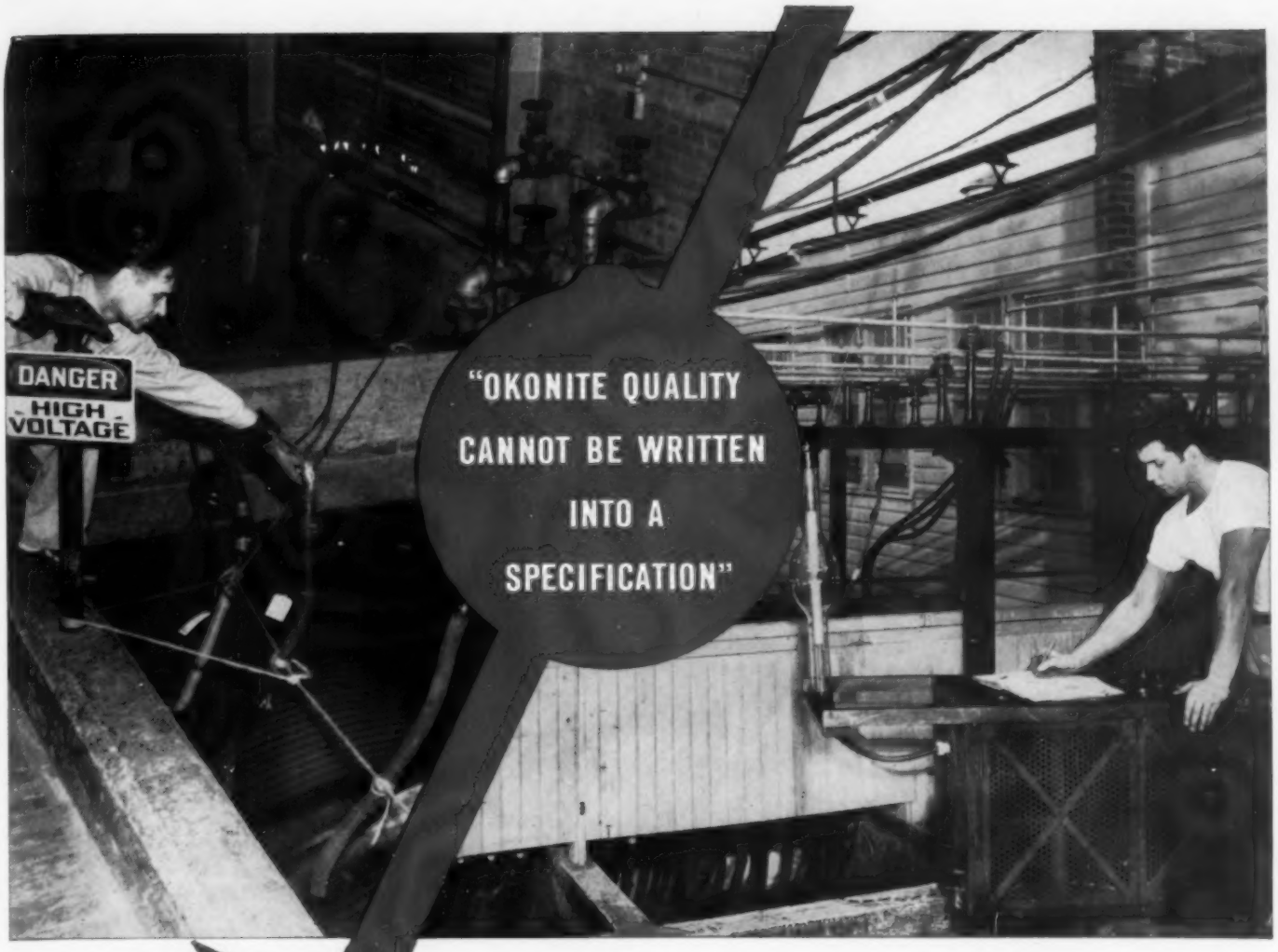
You can't see the LINDE SERVICE that stands behind every UNIONMELT installation to assure its efficient and profitable operation. Only LINDE can give you this unique combination of research, engineering, and over 40 years of welding know-how that is helping LINDE customers save money and improve production. And only LINDE can give you the accumulated benefits of more than 18 continuous years of development, field testing, and improvement in the field of submerged melt welding where it pioneered.

LINDE's Service Engineers will gladly help you design a UNIONMELT installation to meet your exact requirements. They will also be available to help you when a tough production problem comes up. Call your nearest LINDE representative today.

Linde
TRADE-MARK

LINDE AIR PRODUCTS COMPANY
A Division of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

The terms "Linde" and "Unionmelt" are registered trade-marks of Union Carbide and Carbon Corporation.



Specify Okonite by name

Electrical specifications should be written to cover your particular needs, plus an adequate margin of safety. In the case of electrical wires and cables for critical circuits—circuits which *must not* fail—you can be assured of Okonite quality only by specifying Okonite by name.

Okonite quality—that *extra margin* of circuit dependability—cannot be written into a specification. That's because Okonite quality is represented not by any one material or manufacturing technique, but by a vast background of accumulated research, proof-testing and on-the-job experience.

Take Okolite-Okoprene cable, for instance.

Together, the basic Okolite insulation and the Okoprene sheath are the result of an intensive research program and service experience extending back approximately twenty-five years.

Insulation and sheath of Okolite-Okoprene cables are applied by Okonite's exclusive strip process, a cable-making technique used by no other manufacturer in regular production. Only with this process can uniformity and stability be assured.

Ultra-high voltage testing, the highest in the industry, safeguards Okolite-Okoprene against even the slightest imperfections. And of course Okonite's on-the-job performance record has been documented by utilities and industrial plants throughout the country, time and again.

All these "plus" values are obtainable only in Okonite cable. That's why so many cable buyers today make it a point to specify Okonite by name. The Okonite Company, Passaic, N. J.

The best cable is your best policy

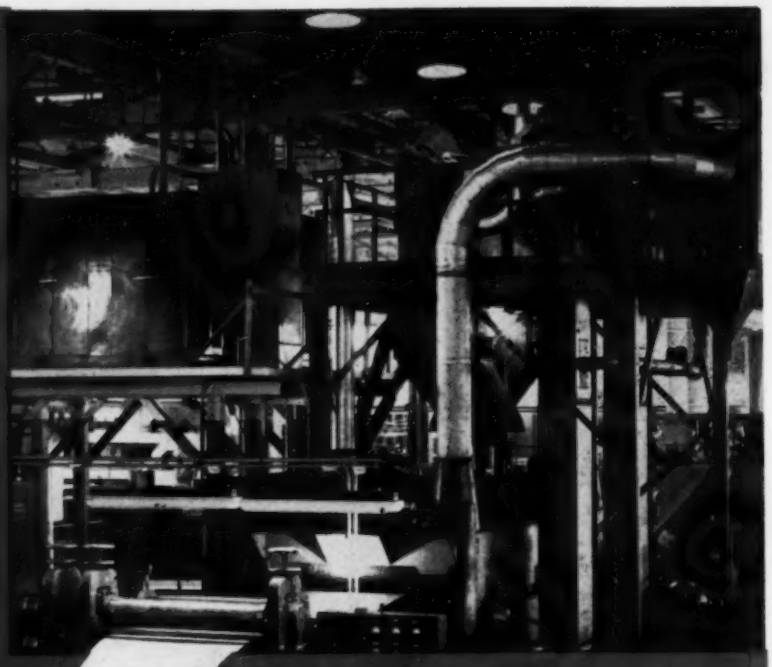
OKONITE SINCE 1878 *insulated wires and cables*

1163

WHEELABRATOR

Mechanical Cleaning

descales steel strip



. . . cheaper than pickling

saves valuable floor space

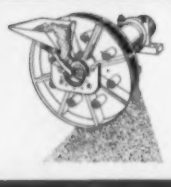
at Rome Cable Corporation

The economies and high speed production of the airless Wheelabrator method of mechanical descaling of hot rolled steel strip are reflected in this typical installation in the Torrance, California plant of the Rome Cable Corporation, manufacturers of electric weld heavy wall conduit.

The airless Wheelabrator method was selected by Rome Cable Corp. because it was the only process that would economically remove surface scale and permit the rest of the plant to maintain its high production without consuming a major portion of the plant area. Whereas approximately 175 lineal feet of floor space would be required for acid pickling, the Wheelabrator cabinet takes up only 25 lineal feet.

The steel strip is descaled prior to slitting for less than the cost of acid pickling. Another important saving is realized in the fact that the Wheelabrator removes scale only . . . there is no loss of virgin metal.

Wherever steel is processed in large quantities, the possibilities for saving money with a Wheelabrator are tremendous. We would be glad to demonstrate these savings for you. Write today for full details.



WHEELABRATOR — The perfected airless centrifugal blast unit pioneered by American scours away scale and dirt mechanically at low cost. Provides a more uniform etch for mill rolls, effects unusual economies in cleaning strip, sheet, bar stock and skelp.

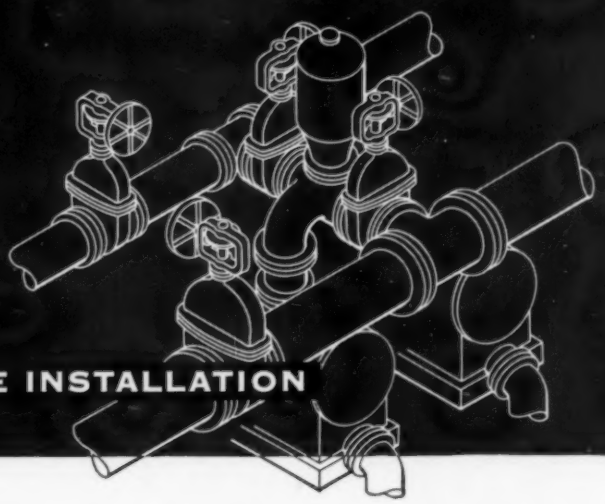
American

WHEELABRATOR & EQUIPMENT CORP.

396 S. Byrkit St., Mishawaka, Indiana

WORLD'S LARGEST BUILDERS OF AIRLESS BLAST CLEANING EQUIPMENT

These Valves Stay on Job After 50 Years of Water Service



THE INSTALLATION

At the Beaumont City Water Works, Beaumont, Texas, with Crane gear-operated iron body gate valves in main lines in pumping plant.

VALVE SERVICE RATINGS

SUITABILITY:	*Always reliable*
FEATURES:	*Rugged design in every part*
MAINTENANCE COST:	*Routine care only*
SERVICE LIFE:	*Still in service—since 1903*
OPERATING RESULTS:	*No valve failures*
AVAILABILITY:	*Crane Catalog item—Current No. 461*

THE CASE HISTORY

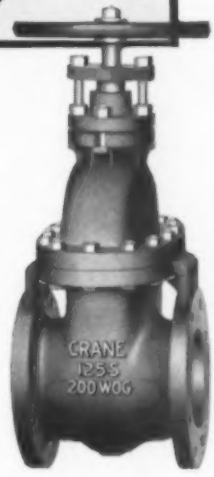
Beaumont taxpayers are still benefiting by the valve quality specified for the Municipal Pumping Station built in 1903. These 14, 16, and 24-inch Crane iron body gate valves remained in their original location until the old plant was converted recently from steam to diesel power. Even then, many were merely cleaned up and put right back in service in the new plant.

For 50 years and more, these Crane valves have given outstanding service at the lowest possible maintenance cost. With but routine care, they remained tight at seat and stem, and always performed with smooth, positive action, despite infrequent operation.

Here's an example of the quality that traditionally sets Crane apart from ordinary valves. It's value like this that has always made Crane the first choice of thrifty buyers in every industry.

THE VALVE

Today's Crane 125-Pound Iron Body Gate Valves with wedge disc are building equally outstanding service records. Highly engineered for durability and dependability at low cost, these valves are now available in the most complete line of patterns and sizes, with a choice of trim for water utilities and other services. Choose to your exact needs from your Crane Catalog, or see your Crane Representative.

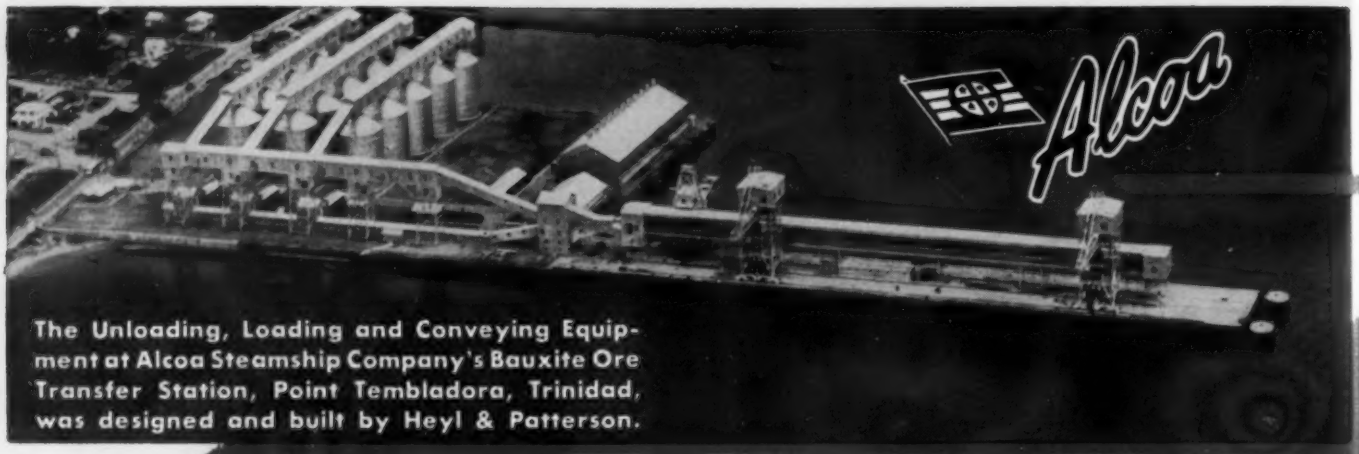


THE BETTER QUALITY...BIGGER VALUE LINE...IN BRASS, STEEL, IRON

CRANE VALVES

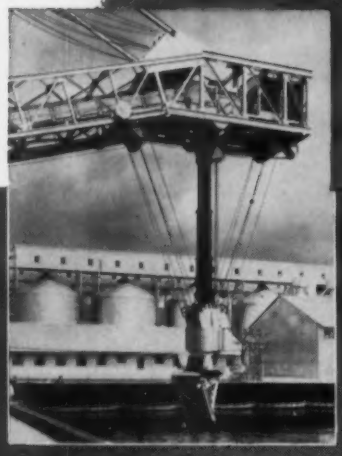
CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING



The Unloading, Loading and Conveying Equipment at Alcoa Steamship Company's Bauxite Ore Transfer Station, Point Tembladora, Trinidad, was designed and built by Heyl & Patterson.

HEYL & PATTERSON
Loading and Unloading Equipment



An easy let down for Bauxite at Point Tembladora, Trinidad by the Heyl & Patterson loading boom, telescoping chute and trimmer.

A quick pick up for Bauxite at Mobile, Alabama by Heyl & Patterson unloading equipment.

IN TRINIDAD . . . At Point Tembladora, Trinidad stands the huge Bauxite Ore Transfer Station of the Alcoa Steamship Company. Here bauxite ore is unloaded from river ships by two Heyl & Patterson Unloaders, and carried by Heyl & Patterson conveying equipment either to the storage bins or directly to the Heyl & Patterson loading facilities where the ore is deposited into the holds of ocean-going vessels.

The H & P telescoping loading chute is especially designed to lower the bauxite ore gently and quickly into the hold of the vessel at the rate of 2000 tons per hour with a minimum amount of dust.

Handles Bauxite Quickly and Easily at both ends of its Caribbean Voyage

IN ALABAMA . . . At the Alabama State Docks, Mobile, Alabama . . . the Ship, loaded with Bauxite Ore from Trinidad, docks alongside of the new Heyl & Patterson Traveling Unloading Tower. The bauxite is rapidly unloaded from the ship and deposited onto a belt conveyor for its first step to the processing plant.

This modern 800-tons-per-hour Unloader . . . designed, fabricated and erected for the State of Alabama . . . currently unloads iron ore and manganese ore as well as bauxite.

The special features of this unloading tower illustrate how it was designed to fit operating conditions at Mobile and why it is one of the finest unloaders in operation today.

(1) The Tower is equipped with an extra-long cantilever which enables material to be transferred from the ship either to the conveyor system or directly to a river barge. In the latter operation the barge is positioned at the opposite side of the ship from the Tower and the trolley moves from above the ship to the extreme end of the cantilever to load the barge.

(2) Because of the short rail spacing between the trucks, the machinery house is placed far to the rear of the tower to counter-balance the weight of the extra-long cantilever.

(3) Adjustable voltage electrical control is used to provide smooth starting and stopping and the fastest possible operation. The use of adjustable voltage lowers maintenance costs and reduces power losses.

(4) The filtered air in the machinery house is kept constantly at a higher pressure than the outside air. This prevents infiltration of dust and prevents overheating of equipment.

(5) The operator's cab is mounted on a heavy ram and moves out over the hold of the vessel when unloading. This enables the operator to have a full view of the hold at all times.

(6) Each bucket of ore can be weighed by means of a force cell application which indicates the bucket weight in the operator's cab.

Heyl & Patterson has never designed or built "catalog" loading or unloading equipment. Every Heyl & Patterson installation is especially engineered to meet the particular needs of the customer.

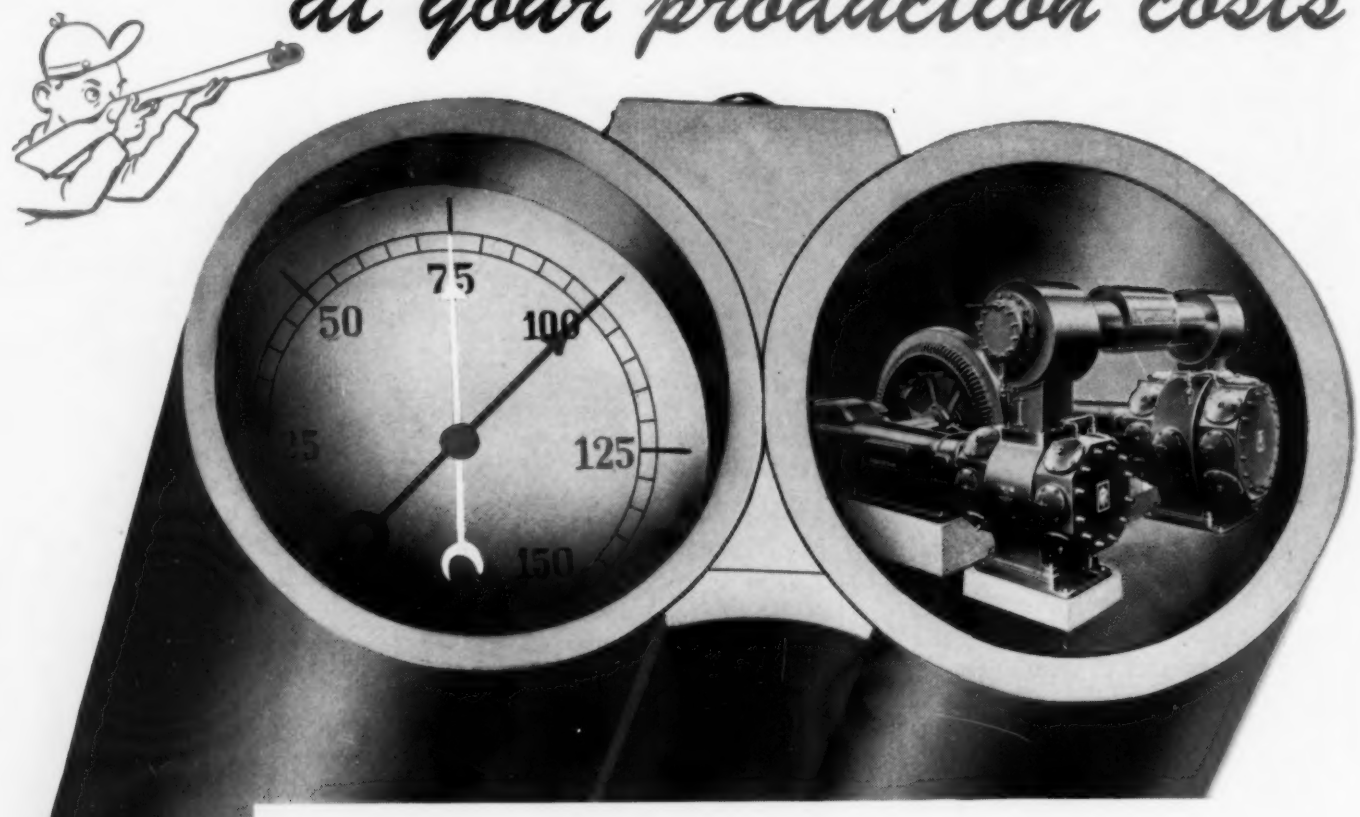
For *YOUR* loading or unloading problem, investigate the advantages of having your installation designed, fabricated and erected by Heyl & Patterson.

Heavy Bulk Materials Handling Equipment *All The Way from Design to Erection*

Boat Loaders and Unloaders
Ore Bridges
High Lift-Turnover-Rotary Railroad Car Dumpers
Coal Handling Equipment
Pig Iron Casting Machines
Cyclone Thickeners
Thorsten Coal Samplers
Car Hauls and Boat Movers
Coal Crushers
Bradford Breakers

Heyl & Patterson, Inc.
"SINCE 1887"
55 FORT PITT BLVD. PITTSBURGH 22, PA.

Fire this DOUBLE BARREL *at your production costs*



1 FULL AIR PRESSURE

Many plants are choking their production and their profits by operating Air Tools on insufficient air pressure. A seemingly small pressure drop of 10 pounds per square inch may cut a tool's productive power as much as 15 to 25%.

Industry is installing new and more Air Tools to reduce its production costs. Why not give these Air Tools a chance to give maximum performance? An I-R engineer will help you make a pressure check . . at the tools. If it's low, perhaps just a change of piping will correct it . larger pipe, or more direct, or new feeder lines. Or possibly you may need more compressor capacity. . at the main plant or at booster stations.

2 MODERN COMPRESSORS

If you need a new compressor, you will want the *best* Ingersoll-Rand's "PRE" synchronous-motor-driven compressor (shown above) is the kind of machine that any plant engineer would be happy to operate . . any company proud to own. These compressors are full of valuable features that you cannot buy in any other compressor ... features that save power, save maintenance. You can't afford to over-look the "PRE" in any modernization program.

"PRE" sizes range from 400 to 3000 horsepower, and if you need smaller compressors, or another type of drive, Ingersoll-Rand has it . . . whatever it is.

Ingersoll-Rand also builds a full line of Air Tools, Air Hoists, and Rock Drills for both production and maintenance work. And remember, Air-Power equipment pays for itself nearly twice as fast today.

AIR POWER ... The Key to Lower Production Costs

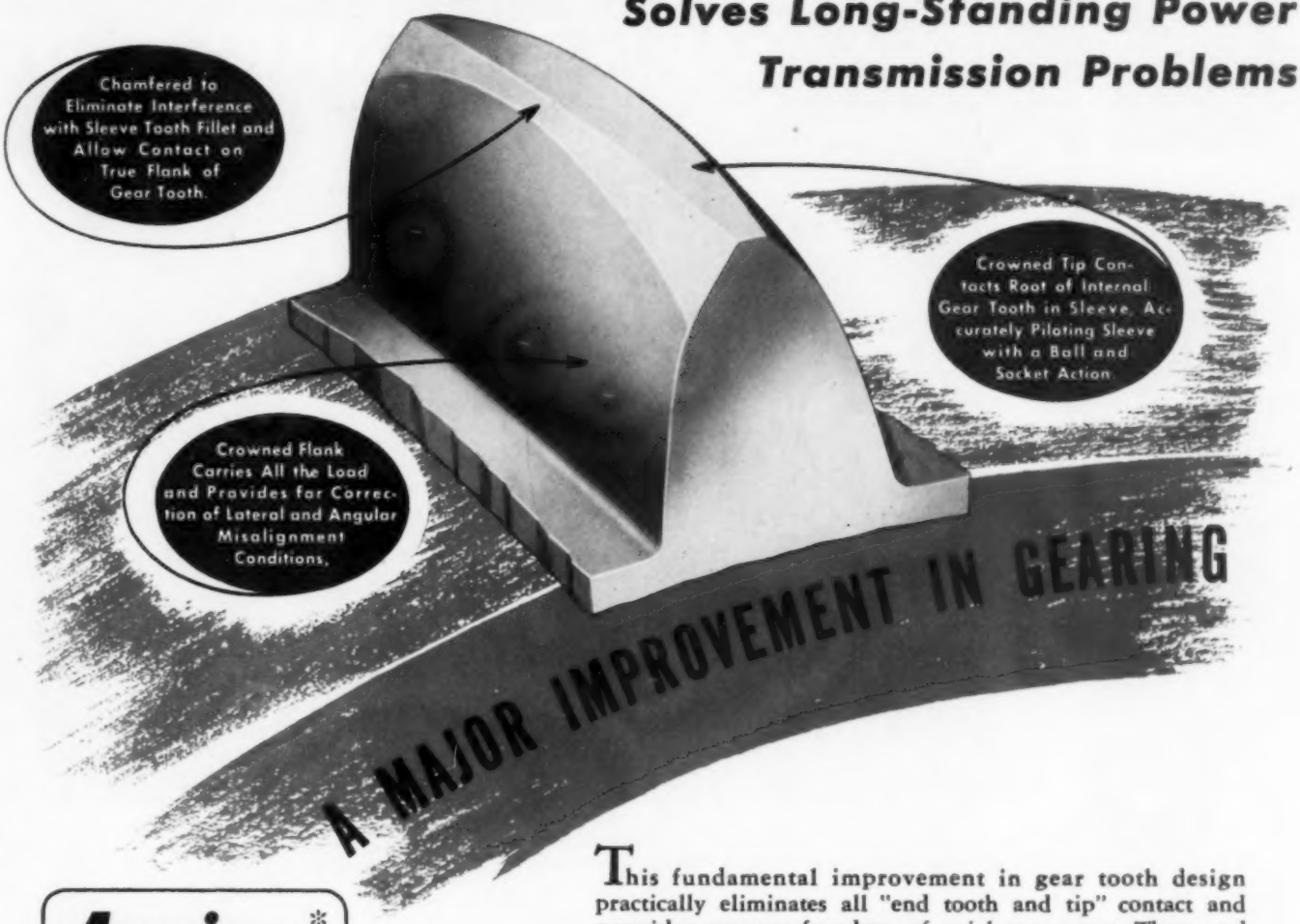
Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y. 380-1

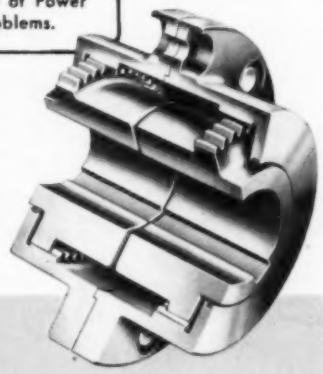
THE Amerigear* FULLY CROWNED TOOTH DESIGN

*Trade Mark Reg.

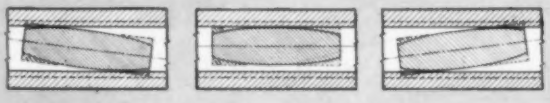
Solves Long-Standing Power Transmission Problems


Chamfered to Eliminate Interference with Sleeve Tooth Fillet and Allow Contact on True Flank of Gear Tooth.
Crowned Tip Contacts Root of Internal Gear Tooth in Sleeve, Accurately Piloting Sleeve with a Ball and Socket Action.
Crowned Flank Carries All the Load and Provides for Correction of Lateral and Angular Misalignment Conditions.
A MAJOR IMPROVEMENT IN GEARING

Amerigear* Fully Crowned Tooth Design Solves Wide Range of Power Transmission Problems.



Oil Seals of Amerigear Couplings Are As Advanced in Design, Performance, and Effectiveness As Is the Amerigear Fully Crowned Tooth.



Comparison of Amerigear Fully Crowned Tooth Design With Gearing of Conventional Gear-Type Couplings Shows How "End Tooth and Tip" Contact Is Practically Eliminated and Why Greater Freedom of Axial Movement Is Provided by Amerigear Fully Crowned Tooth Design (dotted lines indicate gear teeth of conventional gear-type coupling.)

This fundamental improvement in gear tooth design practically eliminates all "end tooth and tip" contact and provides greater freedom of axial movement. These and other exclusive advantages of Amerigear Couplings distinguish them from common gear-type couplings. There are numerous instances where the fully crowned tooth design of Amerigear Couplings has been utilized to simplify power transmission mechanisms and add reliability to performance in a measure heretofore considered impossible.

Amerigear Couplings offer many more advantages than are obtainable with common basic designs. If your problem arises from excessive offset or angular misalignment, tight backlash requirement, space limitations, high speeds and loads, or any combination of these, it can be solved by the use of Amerigear Couplings. Amerigear Engineers are available for consultation.

AMERICAN FLEXIBLE COUPLING COMPANY

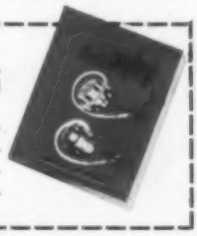
ERIE, PA., U. S. A. ***Originator of the Amerigear Fully Crowned Tooth***

Sales Offices in Principal Industrial Centers

In Canada: Canadian Zurn Engineering, Ltd. • 2052 St. Catherine St. W., Montreal 25, P. Q. Canada

American Flexible Coupling Co., Erie, Pa., U. S. A.
Please send me further information regarding AMERIGEAR COUPLINGS with the Fully Crowned Teeth and Catalog No. 501.

Name ..... *Title* .....
Company .....
Address .....
City ..... *State* .....
Please attach to your business letterhead.



CONDULETS* are ... they're made right

Type LB
Obround Condulet

Type FS Threaded,
With Pilot Lamp Receptacle,
Switch, and Plug Receptacle

Type EPC Explosion-Proof
Motor Starter and
Circuit Breaker
Condulet

Six-spindle automatic screw machine performs six operations simultaneously — makes dozens of hub reducers or conduit union parts every minute.

Crouse-Hinds modern methods produce a superior product . . . to serve you better

Crouse-Hinds factory is equipped with the finest modern machinery, designed for fast, accurate production. To turn out the quality work of which they are capable, such machines require expert handling. Crouse-Hinds machinists have the skill that can come only from long years of careful workmanship. A high percentage have more than twenty-five years of loyal service to their credit. These highly trained machine operators are producing a superior product . . . to serve you better.

More than 15,000 types and sizes of Condulets are listed in the Condulet Catalog . . . a type for every purpose in hazardous and non-hazardous locations.

Always specify Condulets and get the benefit of Crouse-Hinds quality on every job.

When quality counts . . . you can count on Condulets*

*CONDULETS are made only by CROUSE-HINDS

CONDULET
First in the field
STANDARD OF QUALITY

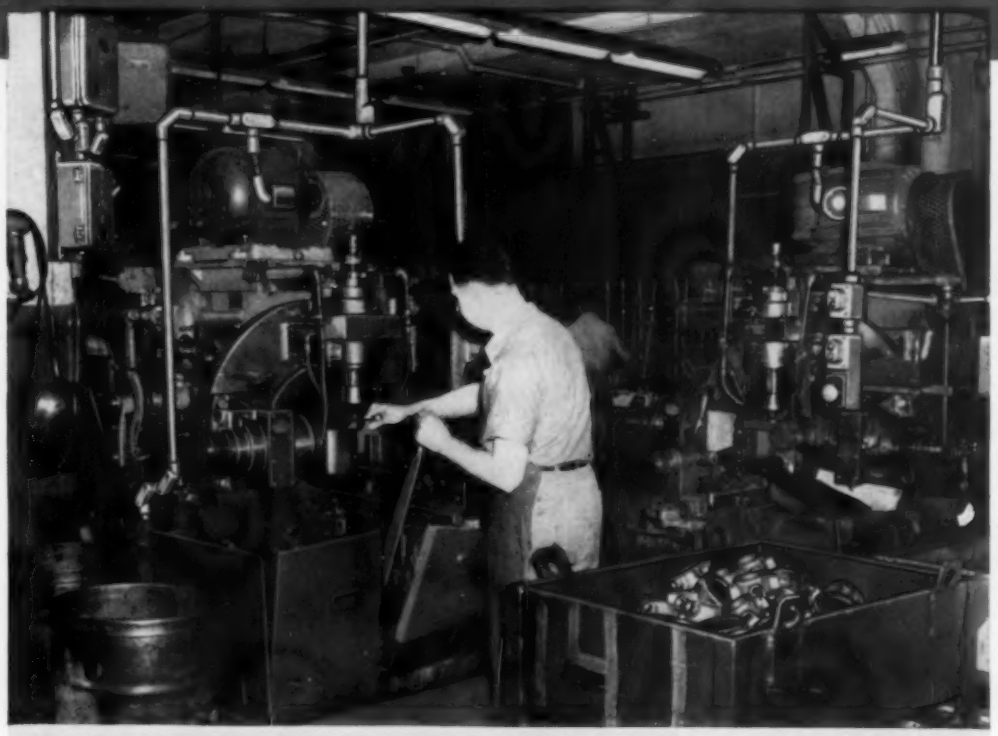
A Nationwide Distribution Through Electrical Distributors

CROUSE-HINDS COMPANY
Syracuse 1, N. Y.

OFFICES Birmingham — Boston — Buffalo — Chicago — Cincinnati — Cleveland — Dallas — Denver — Detroit — Houston — Indianapolis — Kansas City — Los Angeles — Milwaukee — New Orleans — New York — Philadelphia — Pittsburgh — Portland, Ore. — San Francisco — Seattle — St. Louis — St. Paul — Tulsa — Washington
RESIDENT REPRESENTATIVES Albany — Atlanta — Baltimore — Charlotte — Corpus Christi — Reading, Pa. — Richmond, Va. — Shreveport
Crouse-Hinds Company of Canada, Ltd., Toronto, Ont.

CONDULETS · TRAFFIC SIGNALS

tops in quality to last longer



One machinist operates two semi-automatic tapping machines, each of which threads four Condulet hubs simultaneously to insure perfect alignment of the final conduit installation.

Pneumatic wrench is adjusted to provide exactly right amount of torque to fasten globes rapidly and securely into globe holders for explosion-proof lighting fixtures.

Type EVA Explosion-Proof Lighting Fixture

Type FLB Explosion-Proof Circuit Breaker Condulet

Type ARE Plug Receptacle With Spring Door

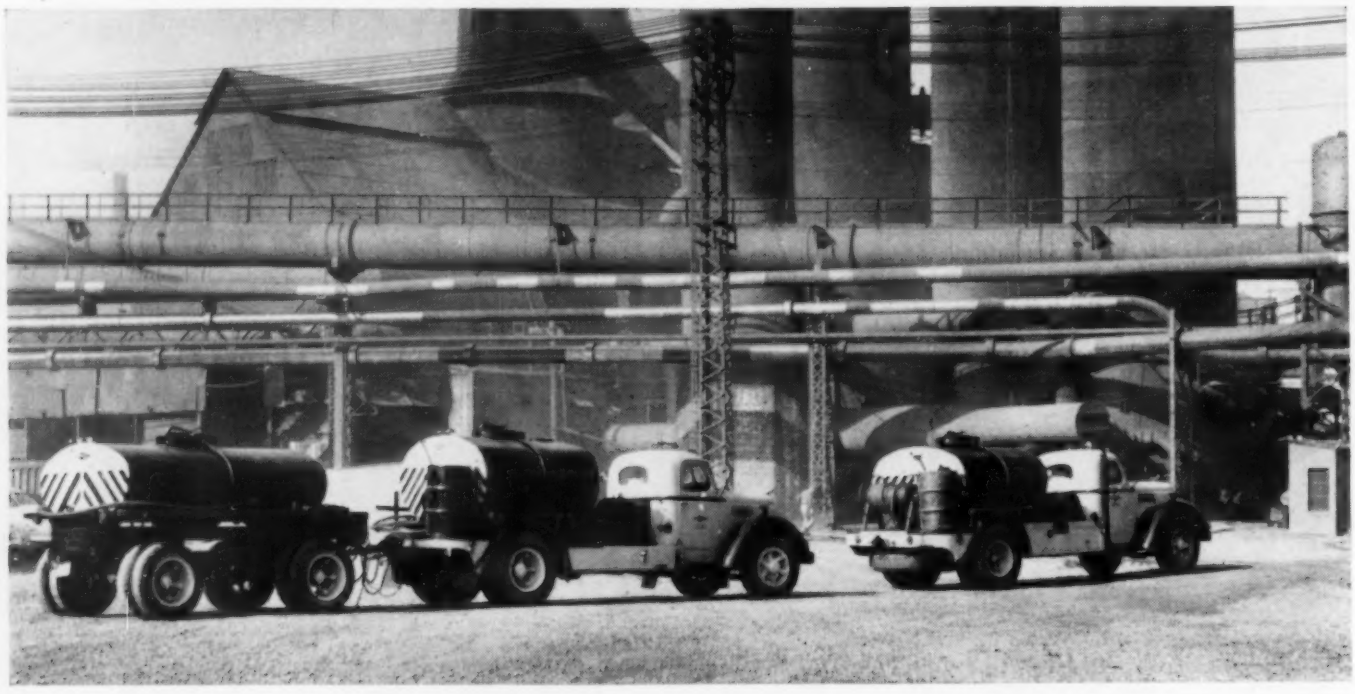
Type LBH Explosion-Proof Condulet For Pulling Cable

Type GUAC Explosion-Proof Junction Condulet

FLOODLIGHTS · AIRPORT LIGHTING

600 FEET OF COKE OVEN GAS MAIN CLEANED CHEMICALLY WHILE IN USE

DOWELL-designed jet nozzle removed brittle deposits from 30-inch gas line under pressure



Tar and naphthalene deposits had accumulated in a 600-foot section of a steel company's 30-inch gas main. The line supplied coke oven gas to a strip mill two miles away. Pressure drop through this line had doubled, forcing the company to buy large quantities of natural gas to supply the strip mill. The company's attempts to clean the line with steam and hot water failed . . . then Dowell was called.

Dowell Service cleaned the line in only three working days, using chemical solvents, specially-designed high-pressure jets and mobile high-pressure pumps. The steel company was especially pleased because Dowell Service did not interfere with the regular function of the line.

What about your maintenance problems? Dowell engineers are experienced in the chemical cleaning of boilers, blast furnace cooling systems, stoves, water lines, gas washers and many other types of steel plant equipment. Dowell engineers use special pump trucks and control equipment to apply liquid solvents by filling, spraying, jetting, cascading or vaporizing. No scaffolding is required. Dismantling and downtime are kept to a minimum. Some equipment can be cleaned in operation.

For more information on Dowell Service and how it can be used to your advantage, call the nearest Dowell office. Or, write directly to Tulsa, Dept. I 29.

DOWELL SERVICE

Over 100 Offices to Serve You with Chemical Cleaning for:

Boilers • Condensers • Heat Exchangers • Cooling Systems
Pipe Lines • Piping Systems • Gas Washers • Process Towers
Process Equipment • Evaporators • Filter Beds • Tanks

Chemical Services for Oil, Gas and Water Wells

DOWELL INCORPORATED • TULSA 1, OKLAHOMA

DOWELL

A Service Subsidiary of
THE DOW CHEMICAL COMPANY

Date-line Diary...

August 3

▲ The AISE reports that operating rate of the steel industry for the coming week is scheduled at 97.1 per cent of capacity. This is equivalent to 2,189,000 tons compared with 2,087,000 tons one week ago.

▲ United Engineering & Foundry Co. reports earnings for the first half of 1953 of $2,043,709 on sales of $39,974,547. This is equal to 82¢ per share as compared with 77¢ per share for the same period in 1952.

▲ Government economists forecast construction spending will reach a new high of $34,500,000,000 this year, up $2,200,000,000 from 1952.

August 4

▲ Cramet, Inc., a subsidiary of the Crane Co., plans the construction of a $25,000,000 plant to undertake yearly production of 6000 tons titanium sponge under a government contract.

▲ United Nations Economic Commission for Europe has reported a decline in steel imports of European countries due to increasing facilities in their own production.

▲ Stockholders of Colorado Fuel & Iron approved increasing number of common shares from 2,900,000 to 5,000,000.

August 5

▲ A leading custom smelter lowered copper price ½¢ to 28½¢ a lb.

▲ The Lake Superior Iron Ore Association reported iron ore shipments continued at a high rate for the week ending August 3. Shipments totaled 3,226,655 gross tons compared with 3,342,127 tons a week earlier, and 2,484,686 tons for the same week in 1952.

▲ Commerce Dept. reported that jobholders in the U. S. in July totaled 63,120,000, a new record for the month.

August 6

▲ Government spending in July was $700,000,000 lower than July 1952.

▲ In London, spot copper closed at 26.3¢ per lb as compared with 31½¢ charged by the Ministry of Materials, the previous sole source of copper for Great Britain.

▲ Economists expect a rise in personal income this year to $285,000,000,000 which is 6 per cent over 1952.

▲ The Commerce Department reported inventories for June 1953 held by manufacturing, wholesale, and retail firms were valued at $77,300,000,000, or $4,800,000,000 above June 1952.

▲ Electricity output rose to a record 8,500,000,000 kwhr last week, up 14.9 per cent from the same period in 1952.

August 7

▲ Chrysler Corp. reported sales of $1,800,000,000 for the first 6 months of 1953 compared with $1,200,000,000 for the like period in 1952.

▲ The Agriculture Department reported exports of grain and grain products for the year ending June 30 dropped to 490,000,000 bushels from 667,000,000 in the previous year.

▲ The Aluminum Association announced production of 623,399,569 lb primary aluminum in the second quarter of 1953 which was 9 per cent over the first quarter and 33 per cent over the second quarter of 1952.

August 10

▲ The Commerce Dept. reported national production of goods and services rose to a record annual rate of $372,000,000,000 in the second quarter of 1953 or $24,000,000,000 above the like period in 1952.

▲ The AISI reports that operating rate of the steel industry for the coming week is scheduled at 96.9 per cent of capacity. This is equivalent to 2,184,000 tons compared with 2,119,000 tons one week ago.

August 11

▲ Sharp declines in wheat ranging up to 10¢ a bushel led commodity cuts followed by coffee which tumbled 2¢ a lb. Cocoa, hides, rubber, cotton and onions stand unstable.

▲ Experts of the Petroleum Administration for Defense expect demand for U. S. petroleum products to continue upward through March 31.

August 12

▲ ARCI reported deliveries of new domestic freight cars in July totaled 6370 compared with 6463 in June, and 5402 in July 1952. Backlog of cars on order as of August 1 was 47,423.

▲ The Agriculture Dept. reported a corn crop of 3,330,418,000 bushels is expected this year. This compares with 3,306,735,000 bushels harvested a year earlier.

▲ U. S. Steel Corp. has under construction a new coal washer at its Robena Mine which is expected to increase daily capacity of cleaned coal to 24,000 tons from present capacity of 16,000 tons.

▲ The Lake Carriers' Association reported the largest ore movement (16,236,316 net tons) for any July, and the shipping industry also set a new record in shipments for a combined tonnage of ore, coal and grain.

August 13

▲ U. S. imports of high grade iron ore from Peru are expected to reach a rate of 2,000,000 tons a year by the end of 1953. Current shipments are about 150,000 tons a month.

▲ Lukens Steel Co. plans to build an additional $10,500,000 armor plate plant at its Coatesville, Pa. works.

August 14

▲ General Motors was forced to lay off over 20,000 workers as a result of a fire destroying its $40,000,000 plant at Livonia, Mich., used for making hydramatic transmissions.

August 17

▲ The AISI reports that operating rate of the steel industry for the coming week is scheduled at 96.3 per cent of capacity. This is equivalent to 2,170,000 tons compared with 2,146,000 tons one week ago.

August 18

▲ The Indian embassy in Bohn awarded two German firms, Krupp and Demag, a contract to construct a major steel plant in India.

▲ International Materials Conference reported that the allocation of nickel among free world nations will be discontinued on September 30.

August 19

▲ Westinghouse Electric announced sales of home appliances reached a new high in July, 99 per cent above July 1952.

▲ AISI announced a new six month production record for the shipment of steel products for the first half of this year at 42,356,861 net tons. June set a monthly record with a total of 6,950,059 tons.

August 20

▲ F. W. Dodge Corp. reported a grand total of construction contracts in July of $1,793,342,000 as compared with $1,115,509,000 in June and $1,511,285,000 in July 1952.

▲ Great Lakes Steel Corp. will rebuild and enlarge its "A" blast furnace at its Zug Island, Detroit plant next spring and thus double its present capacity to 500,000 tons annually.

▲ A leading custom smelter boosted copper prices ½¢ to 29¢ a lb.

August 21

▲ The tin producing and consuming nations will meet in November in an attempt to reach an agreement to stabilize world prices of the metal.

August 22

▲ U. S. Steel Corp. shut down its No. 2 blast furnace at Youngstown for repairs to the lining.

▲ The Engineering News-Record reports heavy construction contracts awarded so far this year total $10,100,000,000 or 7 per cent below the same period for 1952.

August 24

▲ Major steel producers forecast a drop in operating rate for the remainder of the year.

▲ The AISI reports that operating rate of the steel industry for the coming week is scheduled at 94.9 per cent of capacity. This is equivalent to 2,138,000 tons compared with 2,162,000 tons one week ago.

August 25

▲ The American Institute of Steel Construction reports July shipments of fabricated structural steel amounting to 222,016 tons, down 19 per cent from June, but up 61 per cent over July 1952. Contracts closed totaled 213,638 tons. Backlog of work ahead stands at 2,133,517 tons.

August 26

▲ Federal foreign trade authorities predicted shipments abroad should reach about $16,000,000,000 which is $700,000,000 above the high in 1947. Of this, $4,000,000,000 is military aid. Imports are also expected to reach a new high in 1953 of about $12,000,000,000, up $1,000,000,000.

▲ Steel scrap prices have grown weaker in Buffalo and Pittsburgh. In Buffalo, No. 2 grade scrap declined $2.50 a ton to $37 a ton.

August 27

▲ Major auto manufacturers announced a wage increase of 1¢ an hr to workers at General Motors, Ford, and Chrysler because of the Bureau of Labor statistics index rise.

August 28

▲ Internal Revenue taxes hit a new high of $69,700,000,000 for the 1953 fiscal year, 7.2 per cent above the 1952 record.

▲ Detroit Steel Corp. placed into operation a $12,000,000 blast furnace at its Portsmouth, Ohio plant. This will increase pig iron capacity from 250,000 to 750,000 tons annually.

August 31

▲ The AISI reports that operating rate of the steel industry for the coming week is scheduled at 94.6 per cent of capacity. This is equivalent to 2,150,000 tons compared with 2,106,000 tons one week ago.

▲ The Federal Reserve reported consumer credit rose to $27,200,000,000 in July which was $4,500,000,000 above the like period for 1952.

▲ The Commerce Dept. announced manufacturing firms' inventories had a slight hike for July. Previous months had an increase of around $500,000,000 while July showed only $100,000,000 to $45,000,000,000 at the end of the month.

▲ Scrap prices continued to decline and top grades were down $2 a ton since Wednesday, selling at $38.

▲ In line with record sales of $134,500,041 for the fiscal year ending June 30, 1953, Kaiser Steel Corp. declared a dividend of 50¢ per share on common stock.

We Serve Steel Better

Knowing Copper Alloys Best

We specialize in copper and copper-base alloys such as bronze. And we cast these metals for steel industry use by the most advanced methods. For example . . . this aluminum bronze slipper is made by our permanent mold technique and requires *no machining* after casting except for the pin hole. Oil grooves are actually cast-in. Surface hardness is completely controlled, and our customers realize dollar savings through our production-run economies.

National Bearing Division offers you the benefits of more than 50 years of experience, metallurgical research and production-run facility development.

Our 6 centrally located plants are ready to serve you. Contact National Bearing Division for full information.

A FEW NATIONAL BEARING STEEL INDUSTRY PRODUCTS: Bosh Plates • Monkeys • Tuyeres • Coolers • Mantel Plates • Stack Plates • Roll Neck Bearings • Housing Nuts • Babbitt Metals • Slippers

You're invited to visit us at our plant in Meadville, Pa. . . . We'll be glad to have you know us better.

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NATIONAL BEARING DIVISION

4936 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST LOUIS, MO • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

Some furnaces need heat input that varies like this—

Electr-O-Line

PROPORTIONAL CONTROL

is the type to choose for these furnaces. It varies fuel flow by throttling a motor-driven valve in exact response to changes in heat demand. Both proportional and reset actions are provided: proportional control to change fuel flow in relation to the size of the temperature variation; and reset action to correct for sustained changes in furnace load, fuel supply pressure, Btu value of fuel.

Some furnaces need heat input that varies like this—

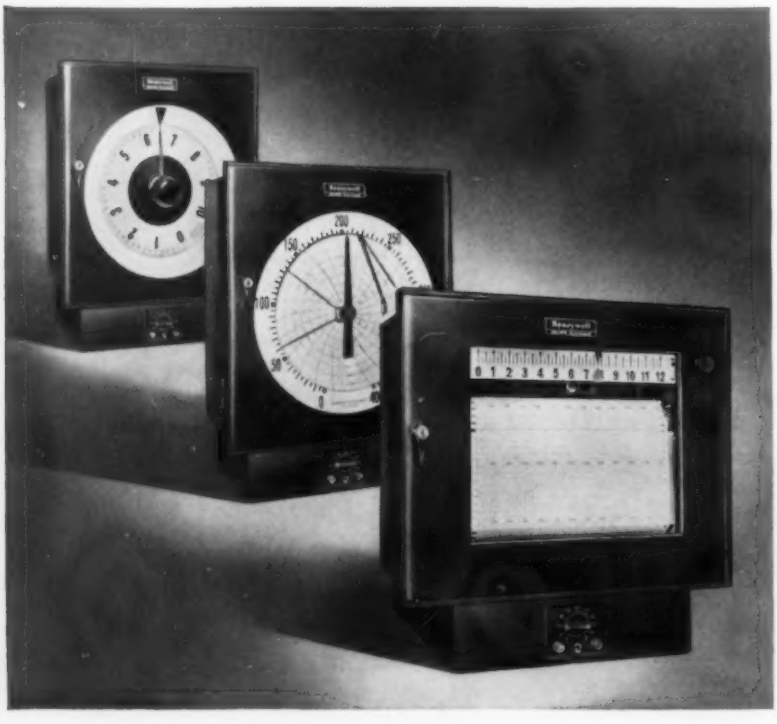
Electr-O-Pulse

PROPORTIONAL CONTROL

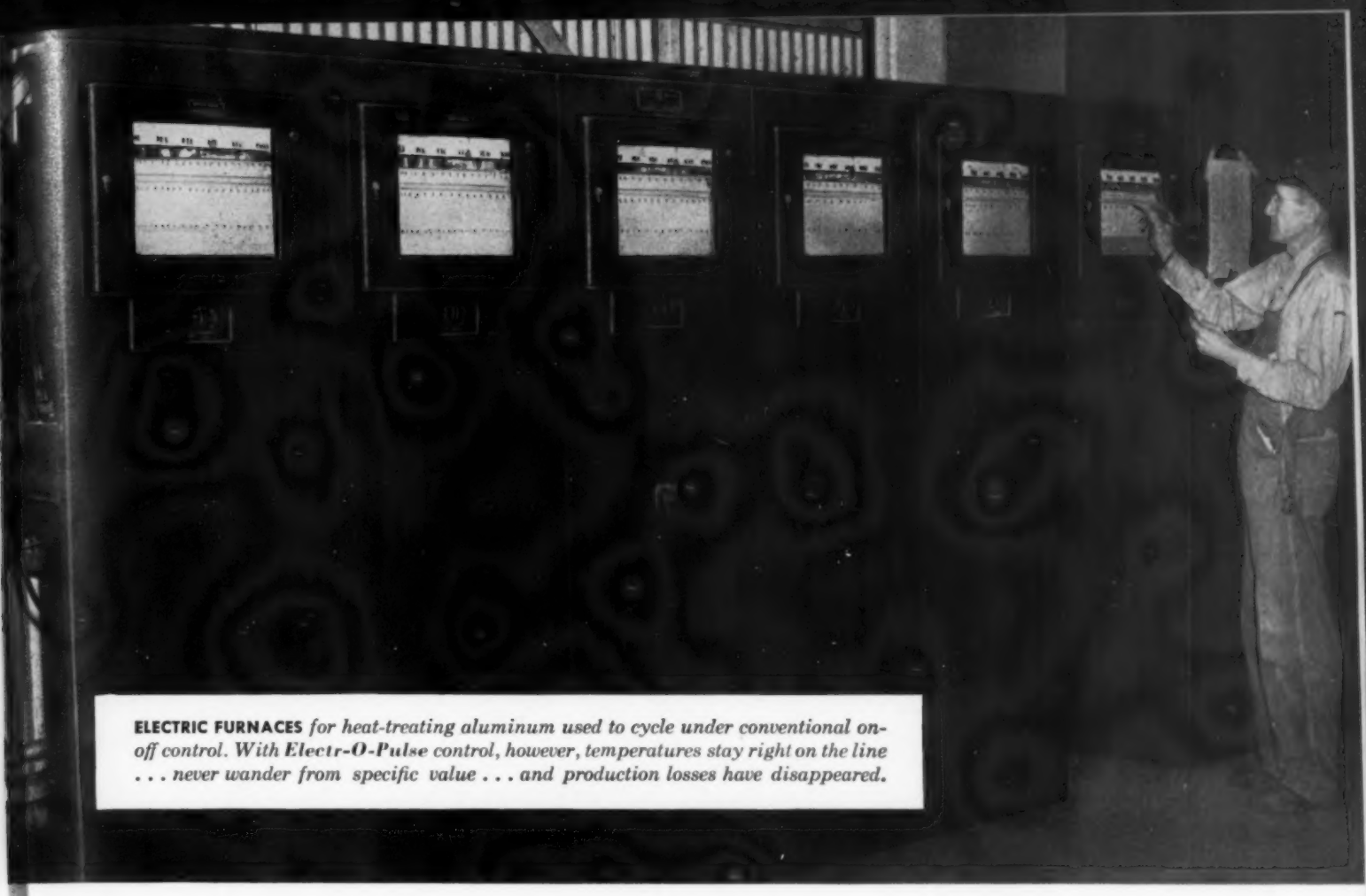
supplies time-proportioning control for electric furnaces and for certain types of fuel-fired furnaces that require this action. It delivers full heat in pulses, controlling the ratio of "heat on" to "heat off" time to regulate average input to balance heat demand. *Electr-O-Pulse* has both proportional and reset actions—regulates a power contactor for electric furnaces, a solenoid or motor-driven valve for fuel-fired units.

Where requirements are less critical, choose Manual Reset Control. It provides the same position-proportioning action as ***Electr-O-Line*** *Control, but reset is manually operated.*

Choose the Honeywell that fits



Any of these ***ElectroniK*** *models can be supplied with* ***Electr-O-Line, Electr-O-Pulse*** *or Manual Reset Control relay, mounted integrally below the instrument.*



ELECTRIC FURNACES *for heat-treating aluminum used to cycle under conventional on-off control. With Electr-O-Pulse control, however, temperatures stay right on the line . . . never wander from specific value . . . and production losses have disappeared.*

electric control *your* furnace best!

YOUR FURNACE will do its best work when it's regulated by the Honeywell electric proportioning control that suits its own requirements most exactly. These systems keep any furnace "on temperature" with precision that spells real profits . . . in lower rejects, greater output, and uniform high quality work. And you gain these further advantages:

1. ***Space saving:*** control relay is an integral part of the control instrument . . . needs little panel space.
2. ***Easy "tuning"*** to your own furnace. Proportional and reset adjustments are entirely independent—do not interact with each other.
3. ***Plug-in design:*** the entire relay is a plug-in unit, replaceable in seconds.

Any *ElectroniK* strip chart, circular chart or circular scale instrument can be supplied, complete with any of the electric control types listed on the opposite page. For modernizing existing installations, the control relays are available separately.

Your local Honeywell engineering representative is well qualified to recommend the type of control best suited to your furnace. Call him in today . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4464 Wayne Ave., Philadelphia 44, Pa.

● **REFERENCE DATA: Write for new Catalog 1530, "*ElectroniK* Controllers."**

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

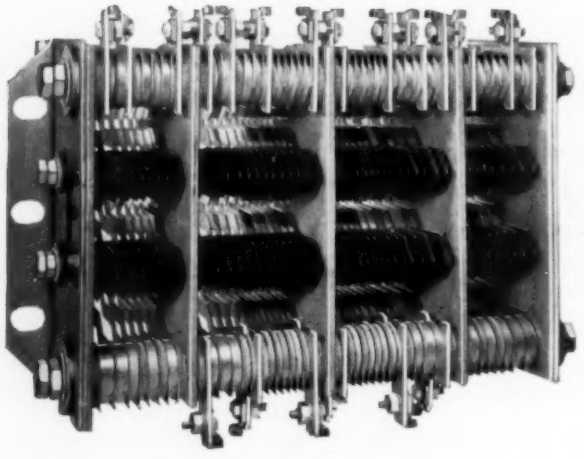
P-G Steel Grid RESISTORS

for Internal Mounting In LARGE and Small FACE PLATE CONTROLLERS

Standard units for 5 to 65 H.P. Motors

Design of the P-G Steel Grid Resistor makes it possible to supply correct ohmic values as well as ample capacity. The ability to meet **both** of these requirements is assurance of accurate control with full protection to motors using either large or small Face Plate Controllers.

All steel construction, mica insulation, provision for expansion, and ample ventilation combine to produce the exceptional stamina called for by today's production schedules.



Standard units for 2 to 25 H.P. Motors

Write for Bulletin No. 500

P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

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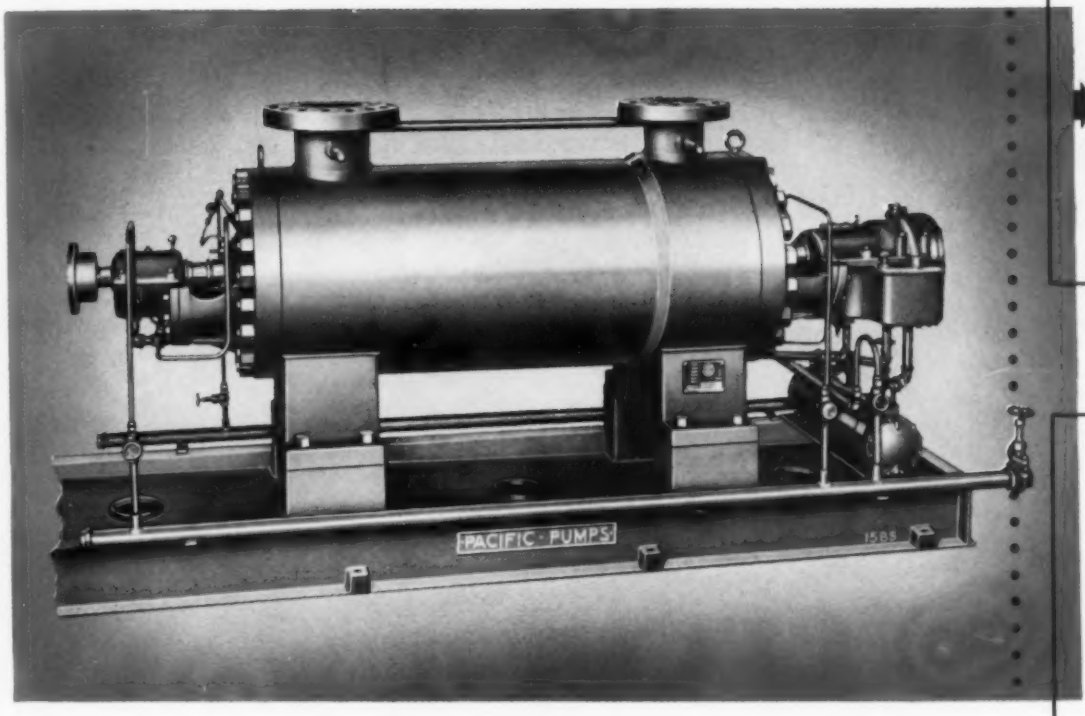
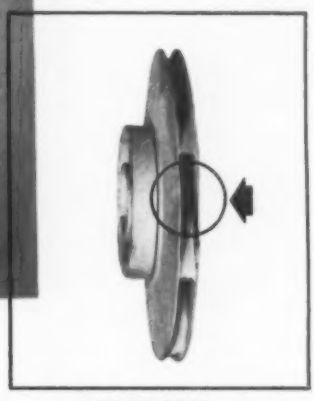
What will Pacific CENTRIFUGAL PUMPS *do for you?*



THE NEW
New impeller ready for installation.



THE WORN
Impeller after 11 years' service.

● *They will last and last . . . give you years of trouble free service!* Pacifics are built in types to meet your requirements . . . they will deliver up to 2700 gallons per minute of cold or hot water at discharge pressures up to 3000 pounds per square inch.

Their strength and toughness is created by using carbon and alloy steels. The bearings for multi-stage pumps are pressure lubricated. Bearings for all types are sealed against dust and dirt. The result is less down time, fewer replacements and much longer pump life. Pacific Pumps *set new service records*—time after time.

PACIFIC *Precision Built* PUMPS

Pacific Pumps inc.
ONE OF THE DRESSER INDUSTRIES

HUNTINGTON PARK, CALIFORNIA
Export Office: Chanin Bldg., 122 E. 42nd St., New York—*Offices in all Principal Cities.*

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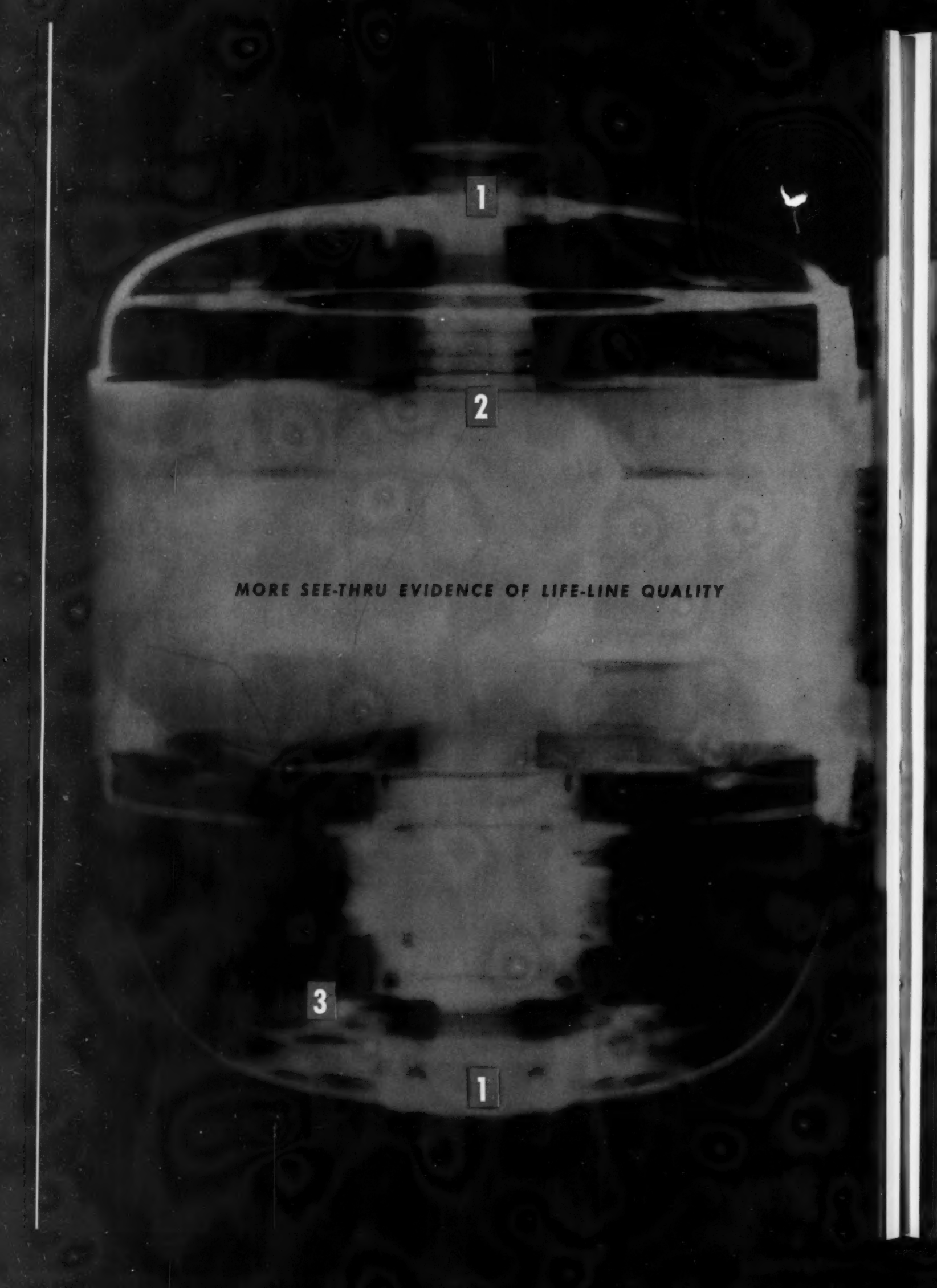
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2
MORE SEE-THRU EVIDENCE OF LIFE-LINE QUALITY
3
1

X-Ray camera probes *Life-Line* d-c motor

1. PRE-LUBRICATED LIFE-LINE BEARINGS

2. PROTECTIVE ARMATURE CONSTRUCTION

3. CAST BRASS BRUSH-HOLDERS

Here, for the first time, you actually look through the muscle and sinew of a ¾-hp Westinghouse d-c motor. Note the Life-Line* construction features that assure dependability in the SK motor line.

Starting with the all-steel frame and feet, you can see the sturdy protection that is built into each SK motor. Angled steel-plate feet are welded right to the frame offering plenty of resistance to shock or vibration.

Pre-lubricated Life-Line bearings—Looking at inset picture #1, you see in greater detail why SK motors never need greasing. This Life-Line pre-lubricated bearing is factory packed with just the right amount of grease . . . specially compounded to inhibit oxidation or deterioration. A double seal on the Life-Line bearing is positive assurance that grease stays in . . . dust and dirt stay out.

Protective armature construction—Inset #2 pictures the SK armature's compact windings of special Tufvar® insulated wire. This enamel insulation provides a tougher, more flexible finish to stand up to heat, moisture or corrosion.

After construction, each SK armature is dynamically balanced to .001″, reducing vibration to a minimum.

Cast brass brushholders — Move your eye to inset #3 and you see at a glance the ease of adjusting or replacing brushholders. The entire assembly is made of cast brass for maximum corrosion resistance. Notice too, that no lever arm is used. A flat steel spring bears directly on the carbon brush. Thus, there are no bearing parts to bind, wear out or jam. Proper brush tension is always maintained.

Investigate these dependable d-c motors by calling your local Westinghouse representative, or write for Bulletin B4595, Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21749

*Trade-Mark

YOU CAN BE SURE...IF IT'S

Westinghouse

4TH COAL BRIDGE

installation at this plant

...proof of satisfactory performance

This new 17-net-ton man-trolley coal bridge is of typical modern Mead-Morrison design. It is a direct ship unloading and stocking bridge, with adjustable voltage control and equipped with a turntable on the man trolley.

This is the fourth Mead-Morrison coal bridge to be installed at this plant; two 12-ton similar bridges having been furnished in 1931, and a third 12-ton bridge furnished in 1942. These three previous installations, two of which are more than 20 years old, are still operating with complete satisfaction.

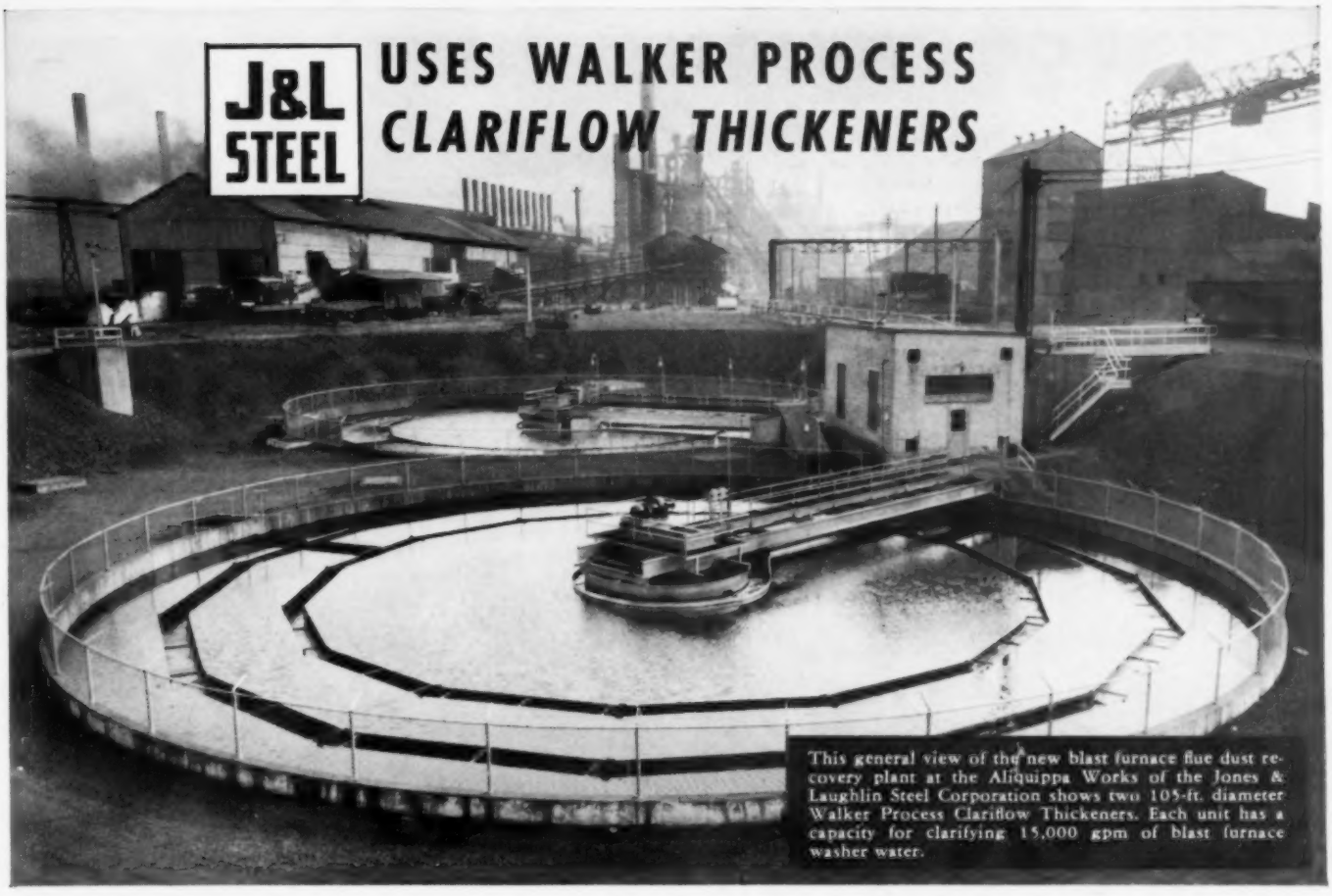
This new bridge was built in 1952 by the Canadian Mead-Morrison Division of United Steel Corporation Ltd. for the Hamilton Plant of the Steel Co. of Canada Limited.

Let our engineers help solve your material unloading and rehandling problems.

MEAD-MORRISON

DIVISION OF McKIERNAN-TERRY CORPORATION · MANUFACTURING ENGINEERS · HARRISON, N. J.

Also builders of ore bridges, coal and ore towers, buckets, pile hammers, and specially designed machinery.



This general view of the new blast furnace flue dust recovery plant at the Aliquippa Works of the Jones & Laughlin Steel Corporation shows two 105-ft. diameter Walker Process Clariflow Thickeners. Each unit has a capacity for clarifying 15,000 gpm of blast furnace washer water.

NEW BLAST FURNACE FLUE DUST RECOVERY PLANT

Removes Over 95% of Settleable Solids!

Single stage thickeners used

Two single stage Clariflow Thickeners were used in the Jones & Laughlin Steel Corporation Aliquippa Works for the following three jobs: (1) to remove over 95% of the settleable solids, (2) clarify the flow to less than five grains and (3) to thicken "mud" to within 40-50% for filtration.

"Short circuiting" at inlet prevented

Balanced rotation at the inlet of the Clariflow Thickener prevents short circuiting and the multiple weir troughs spaced over the entire rise area insure uniform slow rise to the surface of the water being clarified. This assures a clarified overflow containing the least amount of solids.

Thickeners have inlet diffusers

The Clariflow Thickener is constructed for rugged use and is capable of overloading without work stoppage. It is provided with a multiple tangential inlet diffuser so that the flow of material entering the unit is uniformly diffused in a rotating manner.

WRITE FOR BULLETIN 10I69

WALKER PROCESS

CLARIFLOW

thickeners

WALKER PROCESS

WALKER PROCESS EQUIPMENT INC.

FACTORY • ENGINEERING OFFICES • LABORATORIES

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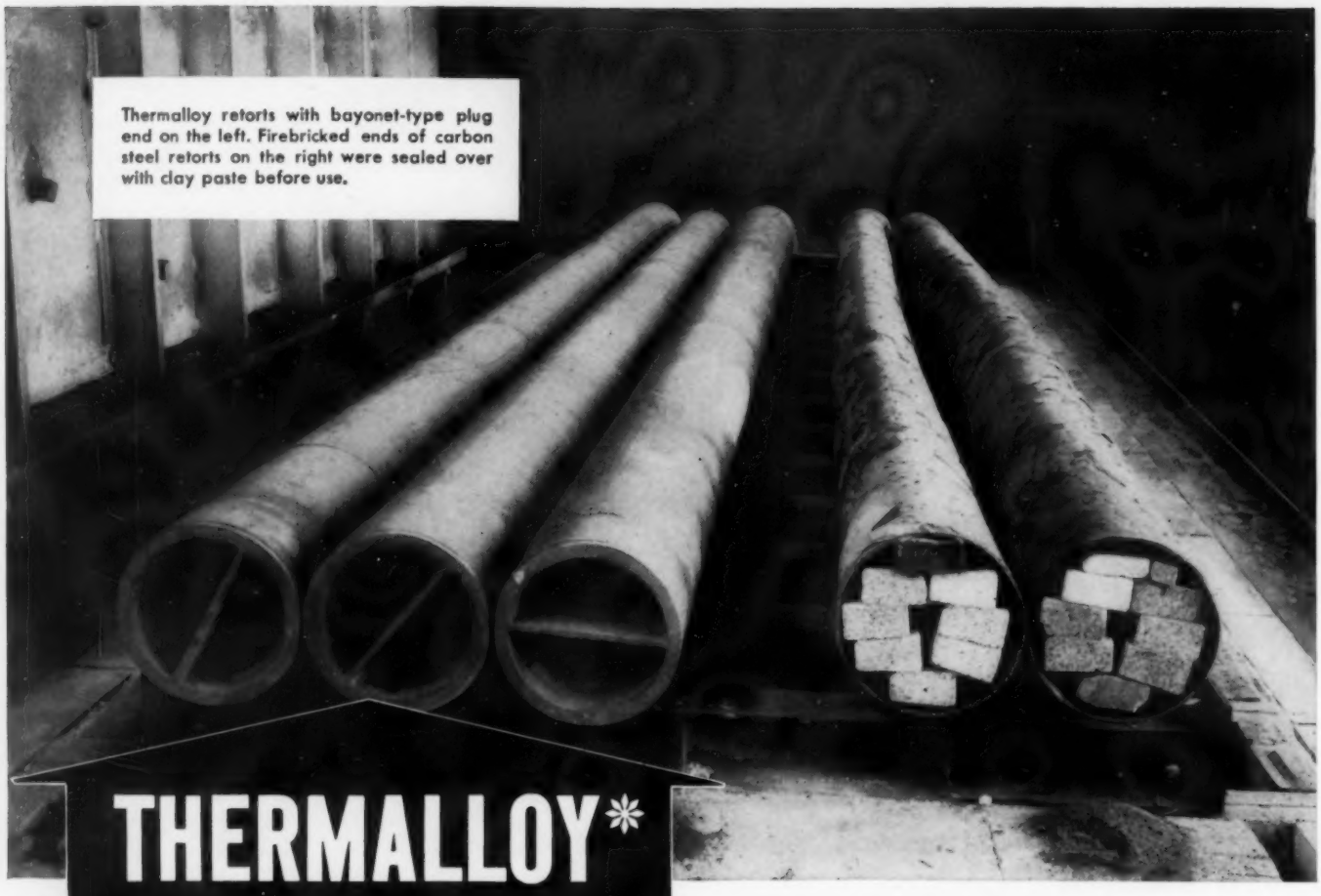

Thermalloy retorts with bayonet-type plug end on the left. Firebricked ends of carbon steel retorts on the right were sealed over with clay paste before use.

THERMALLOY*

outlasts carbon steel retorts . . . 28 to 1

In a plant of a large eastern tool and specialty steel manufacturer, long, pipe-like retorts are used to anneal and heat-treat high-speed carbon and alloy steel bar stock in hood-type furnace equipment. Temperatures range up to 1650°F. during the annealing or heat-treating cycle that may last 30 hours.

Under these conditions, this manufacturer found that wrought carbon steel retorts scaled excessively and also distorted and flattened during operation . . . limiting service life to about 500 cycle hours. For the same operation, centrifugally cast Thermalloy retorts showed no measurable scale loss and maintained uniform wall thickness and shape. When last reported, Thermalloy retorts had been operating over 14,000 cycle hours and were still in perfect condition.

As the wrought carbon steel retorts became distorted, the plugs necessary to seal the open ends would not fit. Firebrick and a clay paste were used to seal the ends against infiltration of furnace gases. This made uniform annealing or heat-treating practically impossible. However, Thermalloy retorts, with plug ends designed by Electro-Alloys, afforded practically gas-tight seals and much greater ease of handling.

Today, this manufacturer is replacing all of the wrought carbon steel retorts with high heat-resistant Thermalloy retorts. Perhaps the same operating economy may interest you in Thermalloy retorts, furnace parts, trays, racks, pots or muffles. For full information, call in an Electro-Alloys engineer or write Electro-Alloys Division, 4007 Taylor Street, Elyria, Ohio.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

the standard of the INDUSTRY

for more than 55 years!

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ALL ALUMINUM CONVEYOR

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POWERED BY AIR GAS or ELECTRIC

Built of **STRONGEST, TOUGHEST,** aluminum
Designed and manufactured by precision engineers who specialize in close tolerances. **SAVES MANPOWER SAVES $ $**

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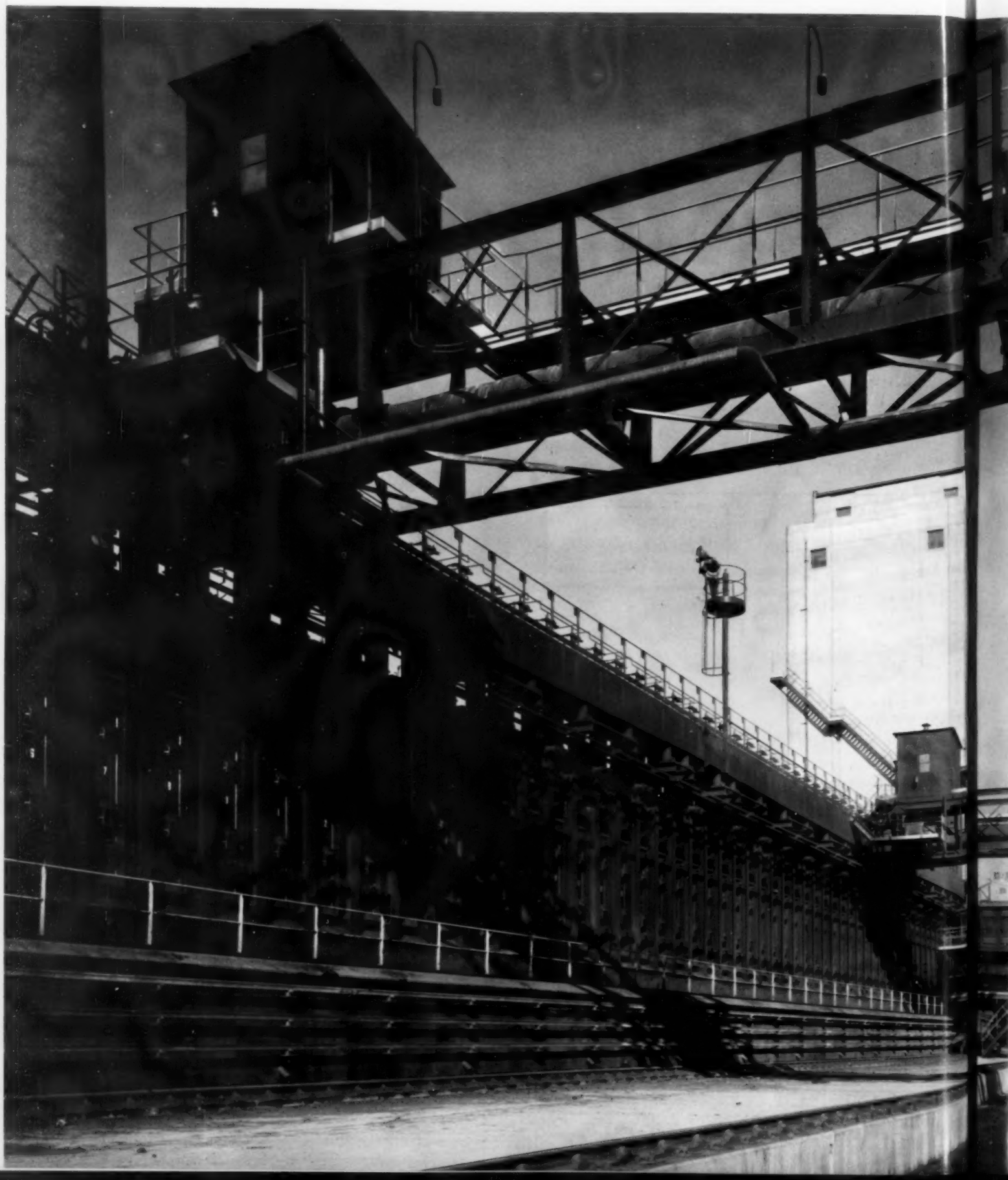
For rebuilding or repairing coke ovens...



...you can count on Koppers

● Koppers has designed and erected a great many coke-oven plants similar to the one shown here. In fact, the constructing of new coke ovens represents a major part of our services to the Iron and Steel Industry.

However, what may not be as well-known are the services we are bringing to bear on the coke-oven repair and rebuilding projects that are now assuming increasing importance in the programing of many companies.

For such projects, we extend to you the same scope of engineering skills and experience, the same meticulous adherence to the client's best interests, the same ability to engineer economies and superior performance into the finished job that have characterized our work on new construction.

Whatever your needs in coke-oven repair or rebuilding as well as for new construction . . . we will look forward to the opportunity of discussing your problems with you.

Constructing, rebuilding or repairing coke ovens is just one way in which Koppers serves the steel industry. For any kind of metallurgical construction, you can count on Koppers.

KOPPERS

Engineering and Construction Division

KOPPERS COMPANY, INC. • PITTSBURGH 19, PA.

A Large Forging Plant Reports on Performance of HAUCK Proportioning OIL BURNERS

A large forging plant, now firing rotary and slot type forge furnaces with 200 Hauck Proportioning Oil Burners utilizing Bunker C Oil, presents the following data on their performance:

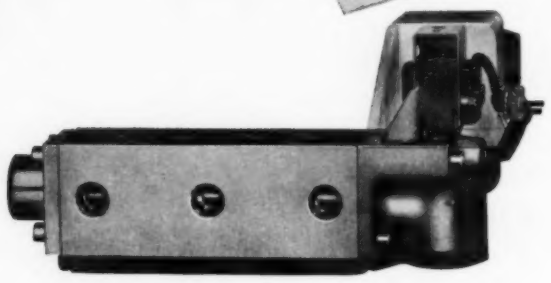
1. Getting cleaner heat with less scaling than was experienced with their old type burners.
2. Heat is more uniform throughout the furnaces, thereby eliminating cold spots previously evident.
3. Easier control of firing with single lever eliminates improper proportioning of oil and air at any burning rate.
4. Since installing Hauck Burners with automatic control they have experienced very little trouble with heating rejects.
5. With better oil atomization and proportioning, carbon trouble and frequency of cleaning have been greatly reduced.

To operate Hauck Oil Burners is to know real performance economy and reliability. Get complete details. Write for Catalog No. 410.

HAUCK MANUFACTURING CO.
Combustion Engineers • Manufacturers of Oil and Gas Burners and Equipment
114-124 Tenth Street • Brooklyn 15, N. Y.

Quick-As-Wink AIR AND HYDRAULIC Control Valves

FEATURE THIS MONTH

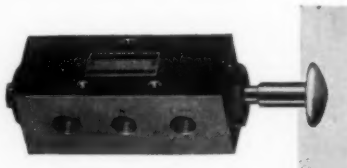


Single Plunger Solenoid Pilot Operated Valves

They'll give you millions of cycles of efficient trouble-free operation

● Quick-As-Wink Solenoid Valves are unsurpassed for positive, trouble-free dependable service . . . they give users millions of cycles of fast, high speed — and safe — operation. All parts are rugged. Low amperage requirement of the solenoid eliminates intermediate relays and simplifies electrical circuits. ⅜" to 2" sizes. 2-way, 3-way or 4-way actions. Bucking cylinder or double solenoid return. Send for the data sheets. Get full details about Quick-As-Wink, America's outstanding valve line, today.

also the following

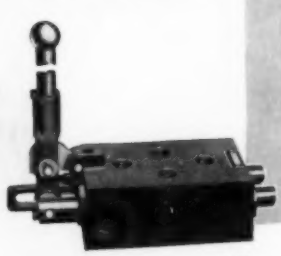


PUSH BUTTON OPERATED AIR VALVES

Push-pull or push and spring return operation — ⅛" and ¼" tapped connections. Widely used for controlling cylinders and many other applications. Air to 125 psi — vacuum—can also be used in low pressure hydraulic service.

LEVER OPERATED HYDRAULIC VALVES

Two position or three position valves ½" to 1½" sizes for line pressures 1000 to 5000 psi. Can be furnished in neutral, compound-exhaust or compound-on actions. Pilot cylinder operated types available up to 4".



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C. B. HUNT & SON, Inc.

Hand, Foot, Lever, Cam, Pilot, Diaphragm and Solenoid Control Valves

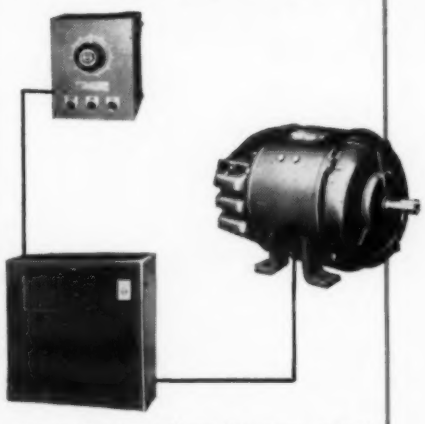
1922 EAST PERSHING STREET • SALEM, OHIO

These facts prove...

RELIANCE V★S DRIVE®

will increase your production with ADJUSTABLE SPEEDS FROM A-C. CIRCUITS

The Original Packaged All-Electric, Adjustable-Speed Drive for A-c. Circuits



Conveniently packaged, factory-wired V★S Drives are available from ¾ to 300 hp. Two or more motors may be operated simultaneously from a single Control Unit.

CONVENIENT CENTRALIZED CONTROL—V★S Drive makes speed changing so easy and convenient that the most economical speed for every operation can always be used. Convenient-to-operate controls are grouped and located where your operator can easily, quickly and safely control all functions of his machine. Controls may be at the machine, or at any remote location, as desired.

STEPLESS SPEEDS—V★S Drive offers an unlimited range of stepless speeds. Operators may change to any speed while machines are running, or may pre-select any speed while machines are at rest, by merely turning the speed adjustor.

CONTROLLED ACCELERATION AND DECELERATION—V★S Drive provides positive all-electric control of torque for breakaway and for acceleration or deceleration. Speed changes may be rapid or gradual, and as frequent as desired. Shockless speed changing with V★S Drive avoids damage to delicate materials or fabrics.

QUICK, SMOOTH STARTS AND STOPS—Quick starts and stops cut lost time between operations. With V★S Drive, any load can be stopped quickly and smoothly, from either high or low speeds, through positive electrical braking that never wears out or needs adjustment.

FAST, FULLY CONTROLLED REVERSING—V★S Drive reverses almost instantly even from high speed. Frequent reversals present no problem. Reversal may be from low to high speed, or vice versa.

INCHING, JOGGING, CREEPING—V★S Drive provides inching, jogging, and creeping, for setting up, threading, positioning, or inspection. Operator can slow down a machine for inspection, then accelerate quickly and *exactly* to previous working speed.

ABSOLUTELY UNIFORM TENSION—V★S Drive maintains proper tension for roll-fed materials so that quality is unvarying throughout and all finished rolls are uniform. Succeeding operations are simplified and productivity of machines is increased. Shutdowns and rejects due to breakage of material, or fluctuations in quality, are virtually eliminated.

MULTI-MOTOR OPERATION—The V★S system makes it possible to apply power to two or more points in a machine or to operate separate sections of a machine tied together as a process. Speeds of motors can be synchronized to any desired degree.

D-1455

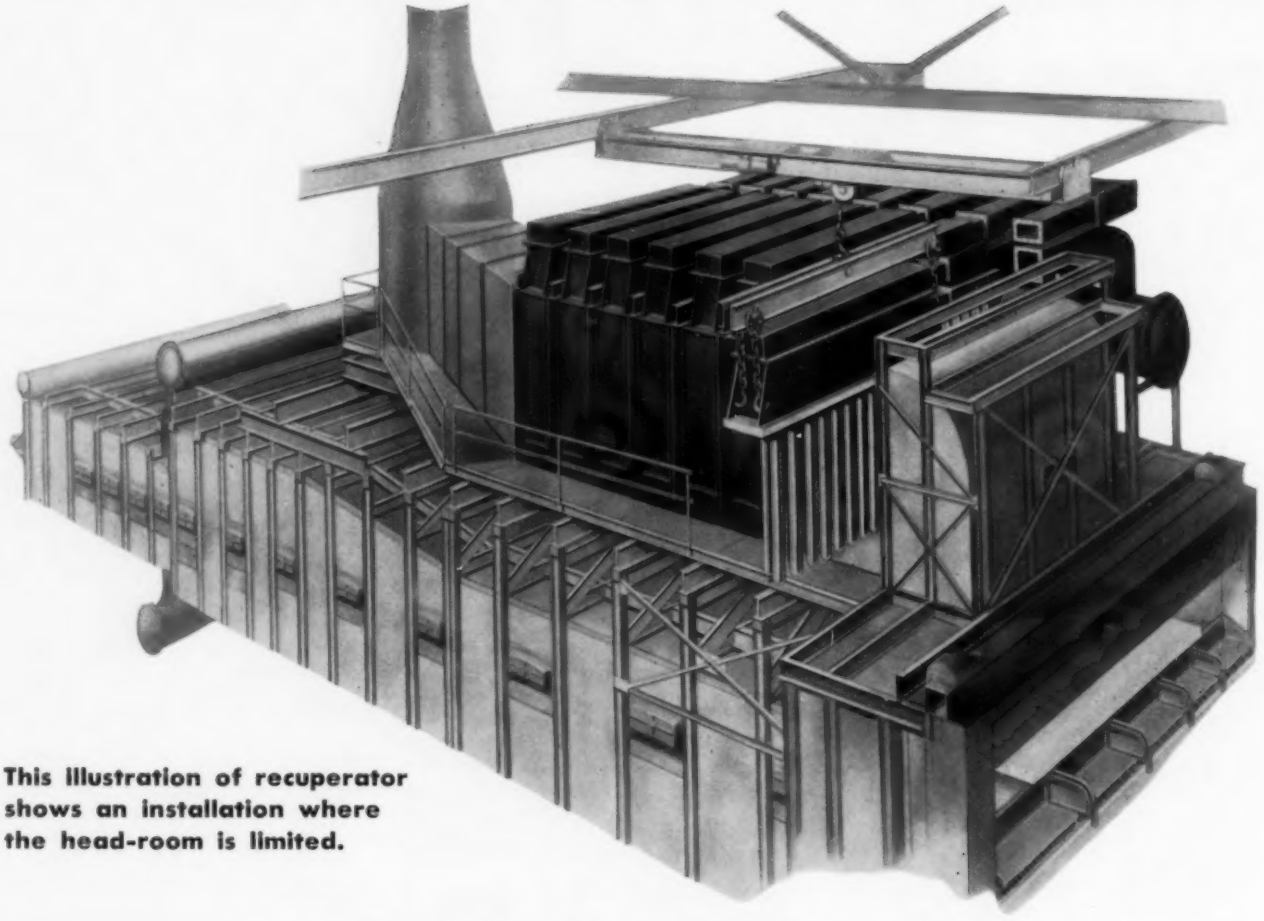
The Most Effective Method of Power Transmission in Industry! Write today for V★S application information and selection data. Ask for Bulletin D-2311.

RELIANCE ELECTRIC AND ENGINEERING CO.

1084 Ivanhoe Road, Cleveland 10, Ohio • *Sales Representatives in Principal Cities*

The HAZEN *Metallic*

FURNACE RECUPERATOR



This illustration of recuperator shows an installation where the head-room is limited.

Check these features

that are guiding leading steel mills to install Hazen Furnace Recuperators.

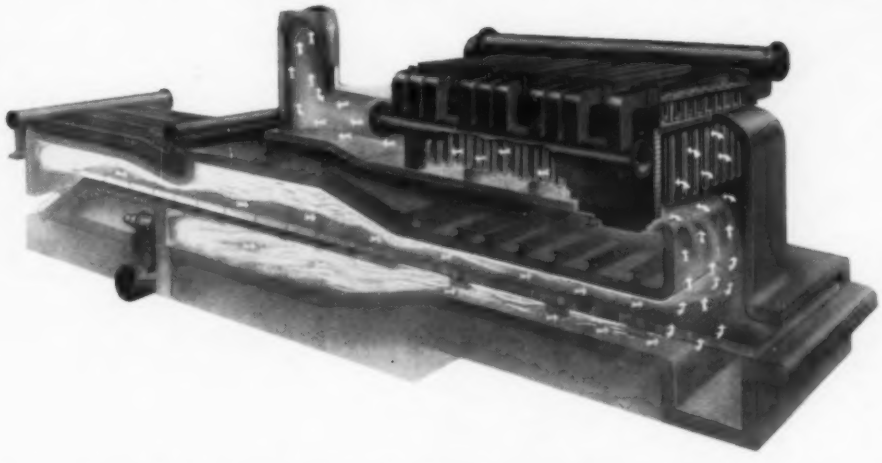
- **Header boxes and recuperator tube assembly can be easily installed or removed as a unit, with small crane . . . minimum head-room required.**
- **Recuperator, flue and stack may be supported from steel work independent of the furnace bindings.**
- **Walkways may be provided around the recuperator for convenience of inspection and cleaning.**
- **Recuperator may be applied above an existing furnace with a minimum loss in outage time.**

Consult us about improving the production and economy of <u>your</u> furnace operations

. . . a logical change to

What Comes Naturally

in the flow of flue gases from the furnace to the recuperator



The above view shows The Hazen Metallic Recuperator located above the furnace. Greater furnace economy is derived when space permits this position.

- This application takes advantage of the natural upward flow of flue gases.
- Less stack draft is required.
- Increased preheat . . . due to availability of a larger percentage of flue gases at higher temperatures.
- Economies in initial cost . . . by reducing the required amount of excavating and furnace foundation . . . by reducing the length of flue ordinarily required from furnace to stack.

CONVENTIONAL APPLICATIONS
RESIST
THE NATURAL UPWARD
FLOW OF GASES

IMPROVED APPLICATIONS
ASSIST
THE NATURAL UPWARD
FLOW OF GASES

HAZEN ENGINEERING COMPANY

PARK BUILDING • PITTSBURGH 22, PA.

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Get McDowell . . . for COMPLETE engineered installation of steel plant equipment: mills, processing lines, materials handling systems, furnaces, docks and dock machinery, etc. . . . plus design and construction of foundations and buildings. The McDowell Method is an intimate understanding of steel making procedures all the way from mine through finished product. Turnkey responsibility is usual.
MESTA
McDOWELL COMPANY, Inc.
CONTRACTORS AND ENGINEERS
3203 W. 71st STREET • CLEVELAND 2, OHIO
McDOWELL METHOD IS A COMPLETE ENGINEERED CONSTRUCTION SERVICE FOR HEAVY INDUSTRY

Industry News...

U. S. STEEL CONSTRUCTS NEW WASHER AT ROBENA COAL CLEANING PLANT

▲ Construction of a new addition to the present coal cleaning plant at Robena Mine will raise the washing capacity to about 24,000 tons daily at this largest U. S. Steel coal mine.

The new ten story structure, located next to the present coal washing plant some 80 miles from U. S. Steel's Pittsburgh district steel plants is expected to be in full operation by the end of this year.

Addition of 50 per cent to Robena's washed coal shipments to the Clairton By-Product Coke works will benefit Monongahela Valley operations of U. S. Steel. Coke made from properly cleaned coal is lower in ash and sulphur and is a contributing factor in producing more and better iron from the blast furnaces.

The new washer, like the original plant, employs two hydraulic waste removal processes. First the coal is introduced into huge cones containing a magnetite water solution, the specific gravity of which is sufficient to float the coal while heavier impurities sink to the bottom. Then the coal flows in water solution across large shaker tables whose ribbed rubber surfaces catch finer impurities. After the cleaning process the coal is transferred by large rubber conveyor belts to storage bins and from there to the tipple where it is loaded into barges for shipment.

The 1600 ton structural framework of the new washing plant was fabricated and erected by U. S. Steel's American Bridge division.

John Durfee, superintendent of the coal washing plant, stated that the washer when completed will produce the highest quality of metallurgical coal. He said the plant is expected to operate on a twenty-four hour basis with a five-day week schedule.

Reese Holmes (left) superintendent of erection of U. S. Steel's American Bridge Division, discusses plans for the new washing plant addition at Robena Mine with John Durfee, superintendent of the washing plant. In the background is the steel framework of the new washer.

BUILD VACUUM FURNACE AT NORRISTOWN PLANT

▲ A vacuum furnace for annealing tubing of the two "new" metals, titanium and zirconium, is being installed at Norristown, Pa., plant of Superior Tube Co. The new furnace is the batch type, can handle tubing in lengths up to 24 ft.

The Superior company is installing the furnace to help meet demand for its recently announced line of small titanium tubing. After six years of metallurgical development Superior has achieved mass production of titanium tubing in outside diameter sizes from .125 in. to 1.500 in., and in wall thicknesses from .004 in. to .187 in. This new titanium tubing is particularly in demand for applications where resistance to high temperatures and corrosion are important.

Because titanium presents many metallurgical problems not encountered with other metals, the seemingly simple task of producing small tubing from this metal on a commercial basis required six years of development. The titanium tubing is now produced by Superior in seamless and weldrawn (welded and drawn) construction.

Zirconium, another metal unknown to industry a few years ago, also presented original metallurgical problems which Superior's metallurgical staff had to overcome to achieve production of zirconium tubing. The availability of raw material of this metal for commercial usage continues to be retarded by close governmental control and consumption. Until this situation is overcome, only minute experimental quantities can be offered to customers.

Another development recently achieved by Superior's engineering staff is the commercial production of thin-wall, seamless, stainless steel tubing in larger sizes than heretofore available. This new stainless steel tubing, ranging in sizes up to $2\frac{1}{16}$ in. outside diameter is also in demand for high temperature and corrosion-resistant application, particularly in duct systems for high-temperature gasses in aircraft.

TO INSTALL EQUIPMENT FOR TURKISH GOVERNMENT

▲ George J. Hagan Co. has received orders from Makina ve Kimya Endustrisi Kurumu for two rotary hearth furnaces, two manipulators, oil conditioning system, one automatic heat treat furnace and miscellaneous spare parts. The above equipment has been purchased on behalf of the Turkish Government and made possible by M S A, installation to be made in Kirrikkale, which is near Ankara, Turkey.

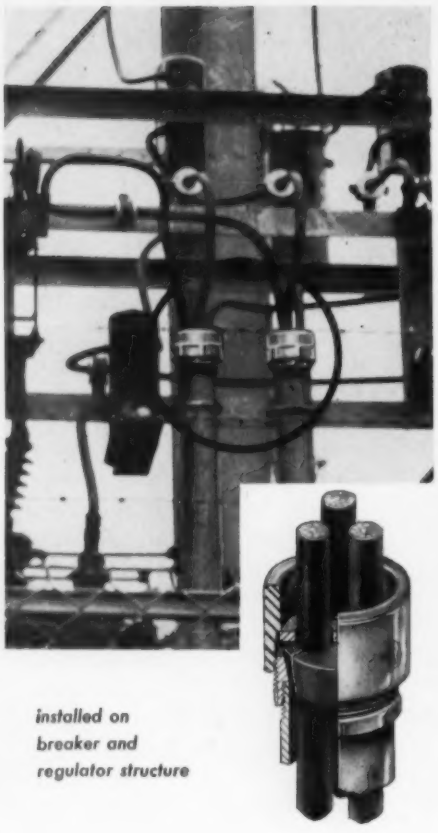
INSTALL LAB ANALYSIS UNITS AT TWO PLANTS

▲ The installation of two production control "Quantometers," most advanced instrument for quick precision analysis of steel at the melting stage, was announced by Crucible Steel Co. of America.

The instrument reduces chemical analysis time to approximately ten minutes, gives more complete data on all metallic elements in the steel and thereby permits better production control and improved uniformity from heat to heat.

The instruments have been installed in the chemical laboratories at Crucible's Sanderson-Halcomb works

McDOWELL METHOD IS A COMPLETE ENGINEERED CONSTRUCTION SERVICE FOR



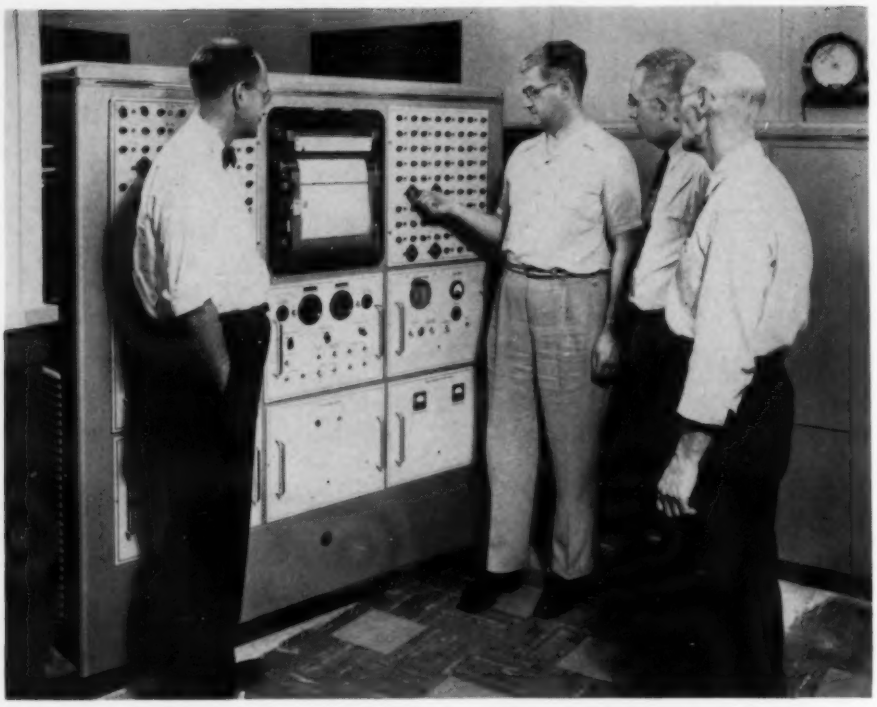
installed on breaker and regulator structure

Cable Supports and Seals

The Adalet "Wedgelock" Supports in the above illustration are engineered for double duty . . . they support the cable, and are compound filled for weathertight terminals. "Sali" wedges are tapered for locked grip. Easy to install.

Write for Bulletin G covering the complete "Wedgelock" series

THE ADALET MANUFACTURING CO.
CLEVELAND 11, OHIO



Shown being inspected at the Sanderson-Holcomb Works of Crucible Steel Co. is a production "Quantometer," to be used for quick precision analysis of steel at the melting stage. A similar unit has been installed in the company's Midland works.

in Syracuse, N. Y., and in the Midland works at Midland, Pa., according to L. L. Ferrall, director of metallurgy.

The Syracuse instrument is the first production control device marketed for the complete chemical analysis of tool, high speed, stainless, low alloy, and high temperature alloy steels. The Midland "Quantometer" is equipped to chemically analyze stainless, low alloy and pig iron.

"Before this instrument was developed," Mr. Ferrall reported, "Many chemical laboratory analyses took at least one-half hour. Depending upon the elements in the steel, a complete analysis could not always be obtained during the melting period. Now, in a matter of minutes, a test can be sent from the melting shop through a pneumatic tube to the laboratory, the sample polished, excited by arc or spark in the instrument, and the complete chemical analysis of all metallic elements present read from a chart and reported back to the melters."

The instrument was built by the Applied Research Laboratories of Glendale, Calif., to fit Crucible's particular needs in laboratories which are required to meet rigid specifications for the most varied range of steel compositions to be found anywhere.

Each unit, consisting of three parts, a high precision source unit, a spectrometer and a recording console, is housed in an air-conditioned, humidity-controlled room to insure the highest accuracy and precision obtainable.

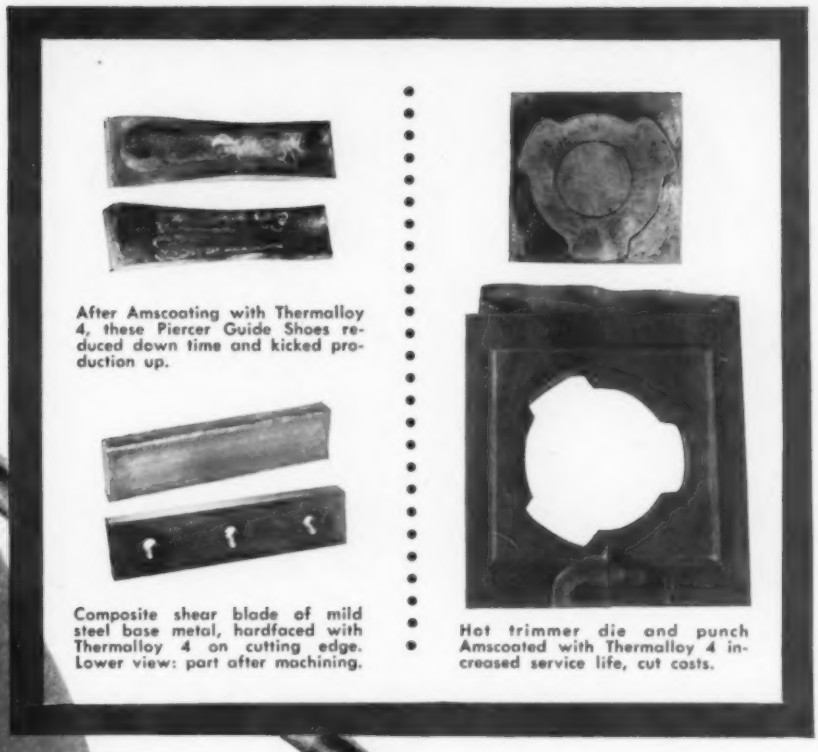
LUKENS PLANS NEW PLATE PRODUCING PLANT

▲ Plans to build a $10,500,000 armor plate producing plant at Lukens Steel Co., Coatesville, Pa., were announced by G. D. Spackman, the company's vice president in charge of operations.

The building housing the new facilities will be adjacent to Lukens present heat treating plant. It will be the same length as the present plant (1000 ft) but slightly larger in floor area.

Authority for the building has been received from the United States Department of the Navy, Bureau of Ships. Construction is scheduled to start in October. Lukens engineers have done preliminary work in relocating a creek and clearing and leveling land to make room for the building, and will design and install equipment in conjunction with the Navy.

A five million-gal capacity reservoir and a pump house will be installed east of the plant. The reservoir,



After Amscoating with Thermalloy 4, these Piercer Guide Shoes reduced down time and kicked production up.

Composite shear blade of mild steel base metal, hardfaced with Thermalloy 4 on cutting edge. Lower view: part after machining.

Hot trimmer die and punch Amscoated with Thermalloy 4 increased service life, cut costs.

BEAT HEAT WEAR and IMPACT with AMSCO THERMALLOY 4

If you have a wear problem involving high temperatures and requiring resistance to impact, this new Amsco hardfacing electrode can save you time and money

Elevated temperatures are tough to cope with in situations involving thermal shock, metal-to-metal wear, hot gas corrosion, high temperature oxidation—especially when you need great impact resistance. Here's where Amsco Thermalloy 4 can step in and give you longer service life, and big savings in time and money.

Supplied as both a composite coated electrode for electric welding or as a bare cast rod for gas welding, both types deposit a high-carbon stainless alloy containing chromium and nickel as the principle alloying elements. In many applications, it can replace expensive nickel base alloy materials. Thermalloy 4 is packaged in 50-lb. boxes or in 10-lb. packages in 50-lb. boxes. For detailed analyses and other pertinent information, write for catalog sheet on Thermalloy 4 or contact your nearest Amsco distributor.

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THE RIGHT WAY TO SAY HARDFACING

AMERICAN Brake Shoe COMPANY

AMERICAN MANGANESE STEEL DIVISION

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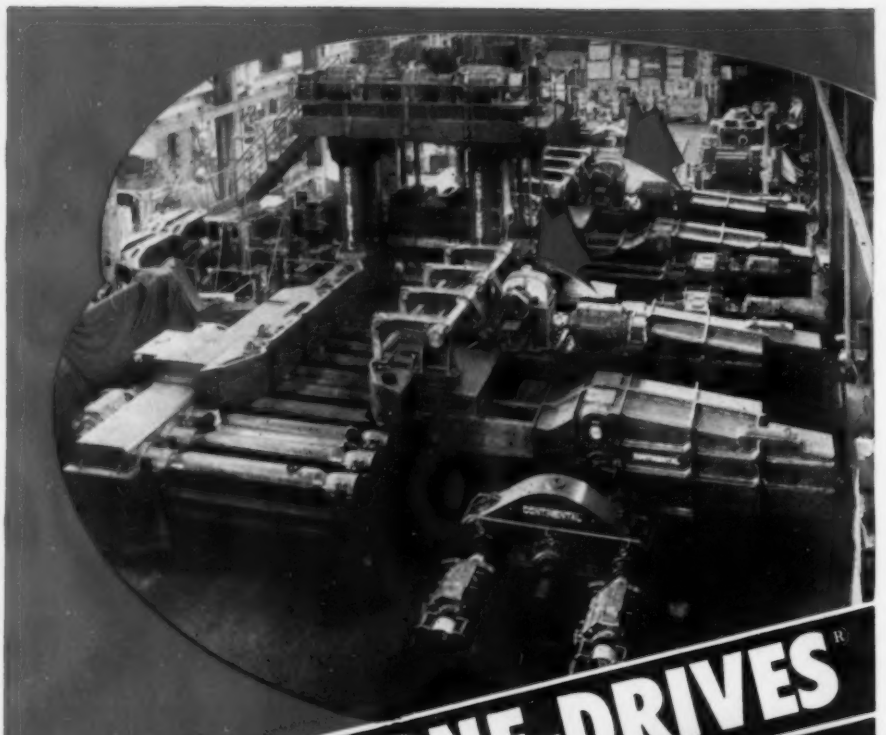
Other Plants: New Castle, Del., Denver, Oakland, Cal., Los Angeles, St. Louis. In Canada: Joliette Steel Division, Joliette, Que.
Amsco Welding Products distributed in Canada by Canadian Liquid Air Co., Ltd.



Rugged CONE-DRIVES® resist shock loads in steel mills

This recently installed 40" Continental Foundry & Machine Company mill performs both blooming and slabbing operations. The power drives are in almost continuous operation and must resist high heat and shock loads—a "natural" for Cone-Drive gearing.

Two standard 18" Cone-Drive reducers are used to transmit 100 hp to the finger manipulators. Two 24" 5/1 Cone-Drive gearsets are also used in the screwdowns. The large number of worm teeth in continuous area contact with the gear teeth not only give Cone-Drive gears their extremely high shock resistance but also their high load-carrying capacity, high safety factor, "hydraulic" smoothness, low maintenance, and long life.

Standard double-enveloping Cone-Drive gearsets and reducers have greater contact per tooth, more teeth in contact, increased load capacity, greater shock load capacity, longer life, lighter weight—and lower overall cost.

Ask for

"Cone-Drive Gears at Work in Industry" (Bulletin #CD-173) for more case histories.

CONE-DRIVE GEARS
Division Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

which will serve the new plant, will be about the size of a football field.

The building will house the most modern armor plate producing equipment, including continuous heat treating furnaces. One furnace will heat plates to 1650 F and will be equipped with a combination spray quench press that flattens red hot plates as they are sprayed with cold water. The second furnace will heat plates to the drawing temperature of 1250 F.

The equipment will include also two cold plate roller-levelers (one to flatten plates up to 200 in. wide and 2 in. thick; the other to flatten plates up to 120 in. wide and ½ in. thick), and a 5000-ton capacity press to flatten plates over 2 in. thick.

Additional facilities include a shear to cut plates up to 1.5 in. thick; a gas-cutting table to handle thicker plates; transfer buggies to handle incoming, in-transit and outgoing plates; and scales, a loading bank and an inspection area. Test preparation equipment, offices for operating personnel, and locker rooms and toilets will be housed in the building.

Based on the potential of Lukens 206 in. mill, and the capacity of the 120 and 140 in. mills, the new facilities will increase greatly the production of armor plate.

The completion of the Navy plant will increase to more than $32 million the value of plant expansions at Lukens since World War II.

ANNOUNCE ADAPTABLE COIL END-WELDING UNIT

▲ A new automatic coil end-splicer that is adaptable to continuous operation involving strip has been formally announced by Arms-Franklin Corp. of Youngstown, Ohio. A long sought answer to the continuous operation of so-called continuous mills and processes, the new method and equipment now permits coils to be end-welded to supply a constant flow of strip to a continuous operation or coil build-up to large, multiple-length coils that make it possible for high speed operations, like cold reduction mills, to operate with fewer shutdowns for material.

Coil end-welding is not a new idea, as the need for a more continuous flow of material was envisioned by the designers of continuous production, processing and fabricating lines years

ago. The problems which have retarded development of such equipment have been the difficulty of producing a satisfactory weld on all grades and gauges of strip, and the complexities of trimming the weld so that it would not mar mill rolls when entering the mill. The welds produced in past efforts to develop a process have tended to be brittle and relatively non-malleable with a resulting high rate of weld severance as strip entered the process line. In addition, welding of light gauges and wide widths were often unsatisfactory and most welds required trimming to avoid roll damage. Waviness in the strip caused high and low trimming which resulted, upon rolling, in various problems such as a roll-over of the high trim with a resulting shearing action, or a tearing or stretching reaction from a low trim with the same end result — severance of the coils.

Key to the success of the new Arms-Franklin coil splicer, which is called "Weld-a-matic," lies in the rapid production of a slim contoured weld that is stronger than the parent metal, so flat that it rolls perfectly without trimming, and is highly adaptable to strip of most gauges and widths. Welds can be produced satisfactorily on carbon steel, stainless, silicon, aluminum, copper and brass.

The process and equipment is fully adaptable to coil build-up for high speed cold reducing operations and for continuous end-welding of coils to provide a constant material flow to processes like pickling, cleaning, slitting, brushing, electric weld tube production and other types of fabricating operations such as stamping and roll forming. A number of installations are in and operating on ferrous and non-ferrous strip although formal announcement of the Weld-a-matic process and equipment had been withheld by the company until development problems had been overcome.

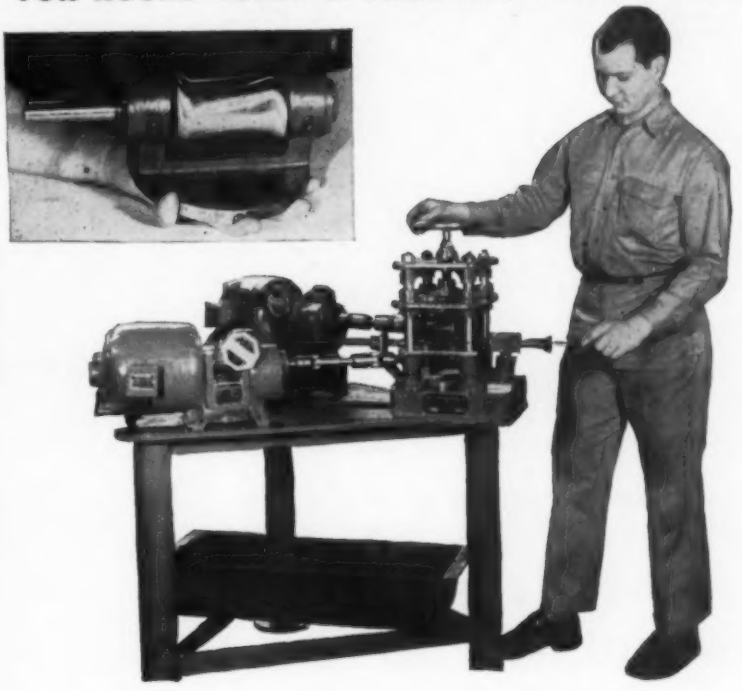
ADD WIRE MACHINERY AT BUFFALO PLANT

▲ Production of high carbon spring wire by the Colorado Fuel and Iron Corp. will be raised by about 12,000 tons annually through the addition of new machinery now being installed in the Buffalo, N. Y., plant of CF&I's

We Build Small Ones Too!

MEDART

No. 000 TWO-MOTOR TYPE
2-ROLL ROTARY STRAIGHTENER
FOR ROUND TUBES & BARS 1/16" TO 3/16" O. D.



• The smallest mill duty 2-roll rotary precision straightening machine made. Straightens, sizes, polishes and corrects out-of-roundness from end to end.

• Individual roll drive from variable speed motors equipped with integral speed reduction units, and interlocked for synchronization of roll speeds.

• Rolls made of Smavroc Alloy. Timken Bearing equipped.

Large Or Small—Medart Builds Them!

2-Roll Rotary Straightening, Sizing & Polishing Machines for tubes and bars from 1/16" to 9" or larger—or multiple-roll straighteners for pipe or thin-wall tubes up to 24". Whatever the straightening job, a Medart machine will do it *faster, better and at lower cost!*

Write For Catalogs

THE MEDART COMPANY 3535 DE KALB STREET ST. LOUIS 18, MISSOURI

THIS PICTURE TELLS A STORY of a new cost-cutting opportunity for steel mills

Note the ready accessibility of each item of steel in this storage yard of a well-known steel mill. It's this availability of materials that's one of the prime advantages of the ROSS STRADDLE CARRIER handling method . . . an advantage, unmatched by any other method, that eliminates delays, lowers costs and increases the production efficiency of the mill.

ROSS STRADDLE CARRIERS, heart of the Ross unit-load handling system, are built to handle 45,000-pound concentrated loads on around-the-clock schedules in the roughest, toughest steel mill service . . . to put those loads *where* wanted *when* wanted.

Your mill, too, can profit by this modern, flexible mass handling system. Get in touch with Ross today for the complete details.

Rely On ROSS

ROSS CARRIER LINE
Industrial Truck Division
CLARK EQUIPMENT COMPANY
BENTON HARBOR 135, MICHIGAN

Wickwire Spencer Steel division, according to A. F. Franz, president.

Two modern continuous wire-drawing machines are currently being added to the wire mill department of the Buffalo plant, and started operations during August, Mr. Franz said.

These machines embody the latest engineering advances in wire-drawing equipment and will substantially increase the CF&I plant's output of hard-drawn spring wire for use in the automotive, mechanical, bedding, and furniture spring industries.

ACQUIRES INTEREST IN PLASTIC PIPE FIRM

▲ Youngstown Sheet and Tube Co. announced the acquisition of an interest in the Perrault Fibercast Corp. of Tulsa, Okla. This concern, which in the future will be known as Fibercast Corp., manufactures glass fiber-reinforced thermo-setting plastic pipe. This product, which is marketed under the trade name "Fibercast," has wide application where full corrosion resistance is required. It will be distributed through Continental Supply Co., Youngstown Steel Products Co. and Youngstown Steel Products Co. of Calif.

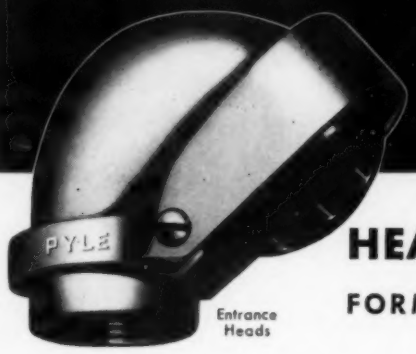
G-E REBUILDS EQUIPMENT AT TWO MICHIGAN PLANTS

▲ Mobilizing a team of 133 General Electric engineers and technicians from throughout the East and Midwest, G-E's large motor and generator department recently overhauled and rebuilt major electrical equipment in two plants of the McLouth Steel Corp. at Trenton and Detroit, Mich., without loss of a single hour's output of steel.

A crew of 14 men with seven tons of equipment was sent from the factory here, while other motor experts came from G-E service shops at Detroit, Baltimore, Philadelphia, New York, Buffalo, Pittsburgh, Chicago, Milwaukee, Richmond, Johnstown, Pa. and Charleston, W. Va.

The men worked 12 hours a day for nine days to complete the overhaul during the plants' vacation shutdown. It is estimated that a similar job done under ordinary conditions would have taken more than a month.

PYLE-NATIONAL
SERVICE ENTRANCE
PYLETS



Entrance Heads

HEADS, CAPS, ELBOWS AND CONNECTORS

FORMERLY MANUFACTURED BY THE M. B. AUSTIN COMPANY

Another important addition to an extensive and continuously expanding line of high quality, heavy duty wiring and lighting products.

PYLE-NATIONAL'S COMPLETE LINE INCLUDES:

Cable Clamp Caps

Entrance Caps

Cable End Fittings

Conduit End Fittings

Two-Screw Connectors

Hexagon-Nut Connectors

Entrance Elbows

Grounding Elbows

Sill Plates

Floor Plates

Corner Elbows

Capped Elbows

- Pylet conduit fittings for hazardous and non-hazardous locations.
- Safety switches.
- Circuit breakers.
- Plugs and receptacles, Triploc, Midget Triploc, Quelarc and Strate-Line.
- Push-button and pilot light Pylets.
- Lighting fixtures, explosion-proof, dust-tight, vapor-tight.
- Junction Pylets.
- Conduit unions.
- Cord and cable sealing grips.
- Floodlights and pit lights.
- Loading lights.
- Gyralite visual warning signals.

Refer to Bulletin 1135 for complete listings... or call your Pyle-National Electrical distributor.

SINCE 1897

THE PYLE-NATIONAL COMPANY

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RED CIRCLE Rolls ALLOY-CHILLED

Red Circle Rolls for all Purposes

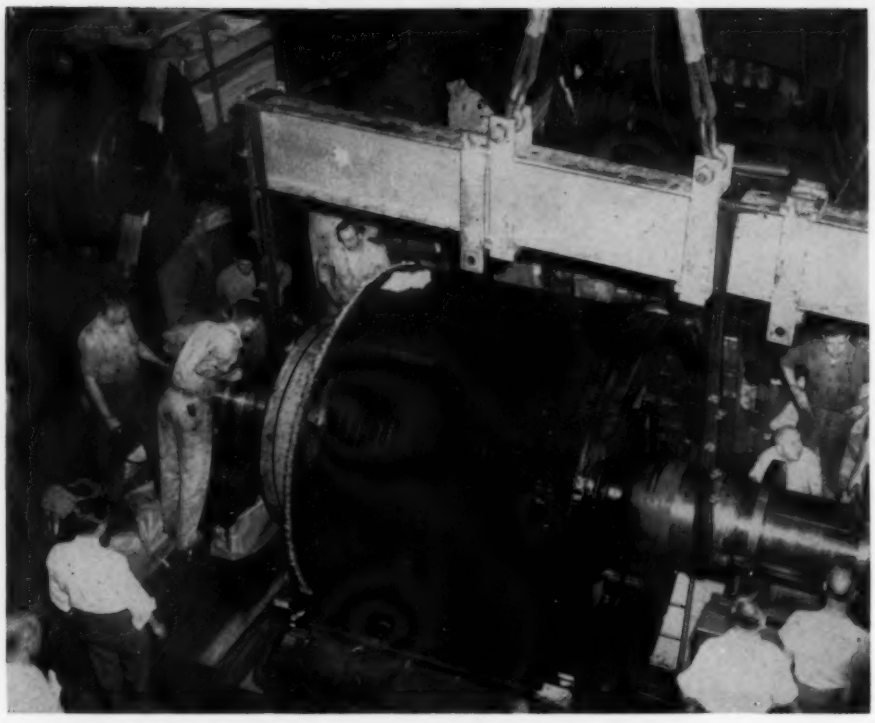
Hyde Park Red Circle Rolls are outstanding in quality and in performance and are easily identified by the Red Circle.

for
finer finish
long life
greater tonnage
Specify Red Circle

Chilled Rolls
Alloy Iron Rolls
Moly Rolls
Nickel Chilled Rolls
Grain Rolls
Cold Rolls
Sand Rolls

Hyde Park

FOUNDRY & MACHINE CO.
Hyde Park, Westmoreland County, Pa.
ROLLS
ROLLING MILL MACHINERY
GREY IRON CASTINGS



One of two rotors used in the main twin-drive slabbing mill motors at McLouth Steel Co., Trenton, Mich. is lowered into place after recent overhaul by G-E technicians.

The primary task was the reconditioning of the blooming mill drive at the Trenton plant. It involved a main motor generator set with a 7000 hp synchronous motor; three 1750-kw generators; two 3500 hp motors, plus cleaning and reconditioning all auxiliary motors and generators and rewiring control panels.

All work was completed without accident. Intimate knowledge of the equipment and use of common techniques resulted in smooth co-ordination of all who participated.

During the work, many unusual problems were met and solved in record time. Special tools and jigs were made on the job; others were brought in from G-E's service shop at Pittsburgh. Brazing equipment was shipped from Schenectady. A spare armature was built and shipped on time.

In the middle of the job, it was found that coils on the huge motors should be replaced. A special messenger brought them from the factory.

Two transformers were found to have burned out because they had to be worked beyond normal capacity. Replacements were flown to the mill.

A special binding band was made up in one day at Schenectady and brought to the job by the manager of manufacturing, large motor and generator department.

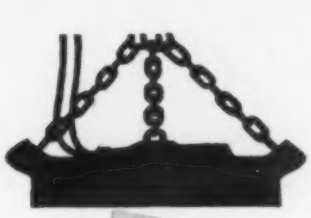
With only one crane available, rigging and moving had to be scheduled for maximum utilization. Typical of the rigging problems was the handling of a rotor weighing 70 tons. The rotor was overhauled and put back in place with a clearance of $^{3}/_{1000}$ of an inch.

All electrical work was finished and tested at 11:45 a.m. on the day before the mill was scheduled to resume production after vacation shutdown. This was 45 minutes later than the original plan, but considerably more work was done than had been planned. At 9:00 p.m. the same day, the mill was ready to roll.

To get an idea of the magnitude of the job, the motors which were rebuilt are two 3,000 hp units which provide a twin-motor drive for a slabbing mill. Each motor is 21 ft long and about 11 ft high. Each rotor weighs 102,000 lb. Combined weight is 614,000 lb.

COMPLETES HEADQUARTERS TRANSFER TO PITTSBURGH

▲ The board of directors of Crucible Steel Co. of America met in the company's Oliver Building offices on August 19 thus denoting the completion of the formal move of the com-



You can't beat **Ohio Magnets** for

heavier construction

OHIO BOLTED MAGNETS. 12 to 65" dia. 6-coil types in 39 to 65"; 8-coil in 55 & 65". Strap coils over 39". Bolts protected in recessed wells. Also capsule-coil over 45".

OHIO WELDED MAGNETS. 39 to 65" dia. Lightweight models in 39 & 45". 6-coil in 46, 55, 65"; 8-coil in 55 & 65". Weld on top where it can't get dented in. Also capsule-coil over 45".

OHIO BASKET MAGNETS. 55 & 65" 4-coil, & 65" 6-coil. For extra heavy-duty service. No weight carried by bolts. Also capsule-coil over 45".

In slag reclamation or rough service—or any use where magnets are subjected to hard knocks—you need the extra heavy construction and greater lifting power of Ohio Magnets.

This super-strong Ohio Basket Magnet has an outer ring with integrally cast fenders that project beyond magnet diameter to ward off and protect against damaging blows. Extra heavy top plate is held in place with strong nickel-steel bolts.

For extra magnet life, extra magnet value—specify Ohio Magnets. Remember, Ohio Magnets lift larger loads longer—*especially with Ohio Magnet Controllers.*

Send for Bulletin No. 112. Offices in principal cities listed in Classified Directory.

Ohio gives prompt service in reconditioning and rebuilding magnets

A-7309

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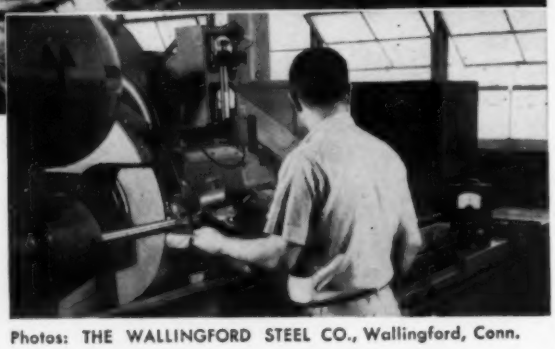
CHESTER BLAND
President

WHERE *Quality Counts...*



ROLL GRINDING CONTROL *with*

Photos: THE WALLINGFORD STEEL CO., Wallingford, Conn.

PRATT & WHITNEY GAGES

When it comes to rolling steel strip, effective Quality Control starts with accurate roll grinding. That's why The Wallingford Steel Company of Wallingford, Conn. — specializing in meeting ***exactly*** the most rigid specifications for gage, finish and temper — has adopted P&W Gaging in its Roll Grinding Department. Shown here in use are:

THE P&W ELECTROLIMIT SNAP GAGE — for the ultimate in dependable accuracy in gaging roll diameter. The Gaging Head is conveniently brought to the roll on the grinding machine; interchangeable frames accommodate rolls from 1½" to 10" diameters. The separate Meter is accurately read at a glance; dual magnification provides direct readings to .00005" or .0001" with full scales of ±.001" or ±.002".

THE P&W ELECTROLIMIT CONTOUR GAGE — for the ultimate in accurately gaging *and* recording roll contour. The Gaging Head is conveniently mounted for testing the roll on the machine and is easy to engage or disengage at any time. The separate Meter and Recording Unit provide an instantaneous visible reading *plus* a permanent record of the roll contour. This latter is a valuable aid to effective quality control and is also used in analyzing roll performance *after* use in the mill. By rotating the roll, this Gage can be used to check "run out" and can also serve to check the machine assuring that centers are on the same axis. Dual magnification provides two scales for convex or concave rolls with readings direct to .00005".

For Complete Information — on Pratt & Whitney Gages for Roll Grinding, write on your Company letterhead to the P&W Branch Office nearest you or direct to West Hartford. Engineering Data Sheets are available and P&W Gage Engineers will be glad to study your requirements and recommend the Gages best suited to your exact needs.

And — be sure to read the facing page; see how P&W Gaging controls the quality of the *finished strip*.

PRATT & WHITNEY
DIVISION NILES-BEMENT-POND COMPANY
WEST HARTFORD 1, CONNECTICUT, U. S. A.

First Choice P&W *for Accuracy*

BRANCH OFFICES AND STOCK — BIRMINGHAM* · BOSTON · CHICAGO
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MACHINE TOOLS • CUTTING TOOLS • GAGES

pany's general offices from New York, N. Y., to Pittsburgh, Pa., which was begun on February 28, 1952, when William P. Snyder, Jr., chairman of Crucible, announced that the general offices would be established in Pittsburgh.

In 1921 Crucible's executive offices were transferred from Pittsburgh where they had been since 1900, to New York. It has been over 30 years since a regular board of directors meeting has been held in the Oliver Building.

Besides the new board room, new offices are being occupied by Wm. P. Snyder, Jr., chairman; W. H. Colvin, president; Joel Hunter, executive vice president; K. R. Vogel, secretary, and S. E. Caron, assistant secretary. This follows the establishment of sales headquarters in Pittsburgh in 1949 under W. H. Wiewel, vice president in charge of sales and operating headquarters there in 1947 under R. S. Poister, vice president in charge of operations. In 1945 metallurgy and purchasing activities were centralized here.

In recent years Crucible has devoted a great deal of effort in expanding and improving its Pittsburgh operations. In 1951, Crucible undertook a $37,000,000 national defense expansion program, consisting largely of major additions to the steel making and processing capacity of the Midland, Pa., works, 35 miles northwest of Pittsburgh. Midland is the company's fully integrated steel plant and volume producer of special purpose steels. Crucible operates the Park works in Pittsburgh (30th and Smallman Streets), a plant producing highly finished stainless steels, machinery steels, hollow drill and drill steels, and numerous bar specialties. Park works and other Crucible plants fabricate titanium and titanium alloy produced by Rem-Cru Titanium, Inc., a Crucible affiliate at Midland, Pa. The Crucible spring works in Pittsburgh produces railroad and heavy-duty industrial steel springs. Crucible's other plants are Spaulding works, Harrison, N. J., center for cold rolled specialties and high alloy cast products, and Sanderson-Halcomb works, Syracuse, N. Y., the tool steel and high alloy specialties center of the company. Trent Tube Co. of East Troy, Wis., producer of welded steel tubing, is a wholly-owned Crucible subsidiary.

ARMCO TO BUILD OFFICE ADDITION AT MIDDLETOWN

▲Armco Steel Corp. announced that construction will begin immediately on a four-story wing to be added to the company's general office building at Middletown, Ohio. Construction cost is estimated at over $500,000.

W. W. Sebald, Armco president, said that the new wing will have about 33,000 sq ft of floor space and should be ready for occupancy around April 1 of 1954.

"The growth of our company has meant larger staff departments in our general office," Sebald said, "and additional office space is badly needed."

In addition to office space, the new addition will include meeting rooms and a George M. Verity memorial library to house historical data on Armco's founder and the early years of the company. An automatic passenger elevator will connect all four floors.

Three floors will be devoted to general office space. The entire wing will be air conditioned, with floors of rubber tile and ceilings of metal acoustical tile. Movable metal partitions will be used throughout the office area.

AGREES TO MARKET TEST INSTRUMENTS

▲ Agreement was reached between Westinghouse Electric Supply Co., New York, N. Y., and Multi-Amp Corp., Harrison, N. J., providing for exclusive national distribution of Multi-Amp portable high current test instruments through the 117 Wesco branches.

To assure adequate coverage in those few states where Westinghouse does not have sales headquarters, special agreements have been worked out with independent electrical distributors.

WILL REBUILD BLAST FURNACE AT ZUG ISLAND

▲ Great Lakes Steel Corp., unit of National Steel Corp., has awarded a contract to Koppers Co., Inc., for the rebuilding and enlargement of the "A" blast furnace at its Zug Island plant near Detroit, Mich.

WHERE *Quality Counts...*

STRIP ROLLING CONTROL *with*

Photos: THE WALLINGFORD STEEL CO'S. SENDZIMIR MILL INSTALLATION

PRATT & WHITNEY

Continuous Gaging

Continuous Gaging for rolling mills — originated, developed and brought to its present state of high efficiency by Pratt & Whitney — has made it possible to improve strip quality, eliminate waste and rejects, and increase average production from 150 to as high as 7,000 feet per minute. It was, therefore, a natural choice when The Wallingford Steel Company of Wallingford, Connecticut selected P&W Continuous Gages for their fine new Sendzimir Mill. The result — strip as thin as .002" is produced to tolerances as close as ±.0001".

As shown here, two types of Pratt & Whitney Continuous Gages are used. The Model D Electrolimit Gage gages the strip from .125" down to .015" in thickness (gage range is .375" to .002"), and a P&W Beta Ray Gage — completely non-contacting — gages strip from .015" down to .002" (gage range is .030" to .0005"). Mounted on a cross slide, either gage can instantly be placed in operating position. Both gages accurately indicate thickness variations to .0001" on the easily read meter located at the operator's control station. As the Sendzimir is a reversing mill (rolling left-to-right and then right-to-left) a set of two gages is installed at each end. All four gages are connected to a Recorder that provides a permanent record of all thicknesses rolled.

If quality control is important in your rolling operations, you'll want to know more about P&W Continuous Gages. Use the coupon below to send for the completely descriptive Circular No. 553. If you have a specific gaging problem, P&W Gage Engineers will be glad to recommend equipment exactly right for your requirements.

First Choice P&W *for Accuracy*

Send For Complete Data

PRATT & WHITNEY
DIVISION NILES-BEMENT-POND COMPANY
28 Charter Oak Blvd., West Hartford, Connecticut

Please send my free copy of P&W Continuous Gage Circular No. 553.

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TITLE_____
COMPANY_____
CO. ADDRESS_____
CITY_____ ZONE____ STATE_____

Here's how to store more power in the same battery space!

...use C&D electric truck batteries

Your trucks will have more power, work stronger and last longer, when equipped with C & D Slyver-Clad* industrial truck batteries.

Ten years ago, C & D pioneered the Five-Fold method of insulation and retention to hold the active material in place on the positive grid and to practically eliminate sedimentation. This reduced size of the sediment space and allowed the use of longer and heavier plates. In C & D Slyver-Clad batteries, you get 20% more capacity—*in the same-size tray!* And, because "shedding" is also virtually eliminated, a C & D Slyver-Clad Battery lasts longer and delivers maximum capacity at the very end of its life. The next time you replace an industrial truck battery—*install more power in the same space*—install C & D!

*TM Reg.

WRITE FOR SPECIFICATIONS!

For complete descriptions and specifications of C & D Slyver-Clad Industrial Truck Batteries, write for Bulletins IT-517 and IT-518.

C&D

BATTERIES, INC.

of Conshohocken, Pa.

Manufacturers of Industrial Batteries since 1906

SALES AND SERVICE OFFICES IN PRINCIPAL CITIES FROM COAST TO COAST

Work on the project will start next spring. When completed, the rebuilt furnace will have a capacity of approximately 500,000 tons per year, which is twice as large as the capacity of the present furnace, and will increase the total annual pig iron capacity of the Zug Island plant to about 2,000,000 tons.

This addition will help to provide the larger quantity of raw materials required because of National Steel Corp.'s expansion of steel making capacity which will reach the 6,000,000-ton mark by the end of this year, and which is an increase of more than 50 per cent since 1945.

The rebuilt furnace will be almost identical with the new Great Lakes "D" furnace which started operation in September, 1952. It will be of Freyn design and engineering work is now underway at Koppers' Freyn division. The furnace will be 109 ft high and have a hearth diameter of 28 ft. It will be equipped to operate with increased top pressure and all auxiliary facilities will be of the most modern design.

TO SELL COLD ROLLED STEEL ON OPEN MARKET

▲ Metal product manufacturers in central New England had a local source of cold rolled steel reopened to them recently when the Worcester Pressed Steel Co., Worcester, Mass., announced that once more the products of its cold rolled mill were to be placed on the open market.

Carter C. Higgins, president and general manager of the Worcester company, announced that capacity at its steel mill permitted sales to other manufacturers who could thus take advantage of shorter haul freight rates by buying within the industrial community.

The steel selling program means that Worcester facilities have again been broadened and used by other producers. Particularly useful to other producers has been the rerolling operations which have permitted manufacturers to meet steel shortages or to buy steel at favorable prices. They then have the steel processed at the mill to required specifications. One company alone has had 2,000,000 lb of steel rerolled for its needs through these facilities.

Good news for Buyers of Rolling Mill Auxiliary Equipment

LAKE ERIE expands mill machinery division to provide complete equipment, and design, engineering and rebuild services.

For many years LAKE ERIE has been a regular supplier of specialized equipment and services to mills in the Buffalo area...and elsewhere occasionally. This has included the rebuilding of complete mills and drives. The LAKE ERIE services have now been expanded to take care of any requirement... anywhere, ferrous or non-ferrous, for Auxiliary Strip, Sheet and Coil Handling and Processing Equipment. Ask LAKE ERIE to quote on your next requirement. Judge for yourself the advantages of dealing with one of the most completely equipped plants and experienced staffs in the heavy machinery field.

THE FOLLOWING WILL SERVE AS A BUYING GUIDE WHEN YOU ARE CONSIDERING REPLACEMENTS OR ADDITIONS

INDIVIDUAL UNITS

Mill tables and conveyors • Coilers and uncoilers
Shears, up-cut and down-cut • Pay off and take up reels • Stretcher levelers
Wet and dry scrubbers • Scrap ballers and balers • Turn tables
Dancer roll units • Belt wrappers • Slitters and side trimmers
Roller levelers • Pilers and unpilers • Coil ramps and coil boxes
Oiling machines • Dryers • Upenders and downenders
Tension bridles • Shear gauges • Peelers and processors

COMPLETE LINES

Coil build up lines • Sheet pickle lines • Sheet and strip shearing lines
Cleaning lines • Strip pickle lines • Resquare lines
Slitting lines • Annealing lines

PLUS REBUILD SERVICES

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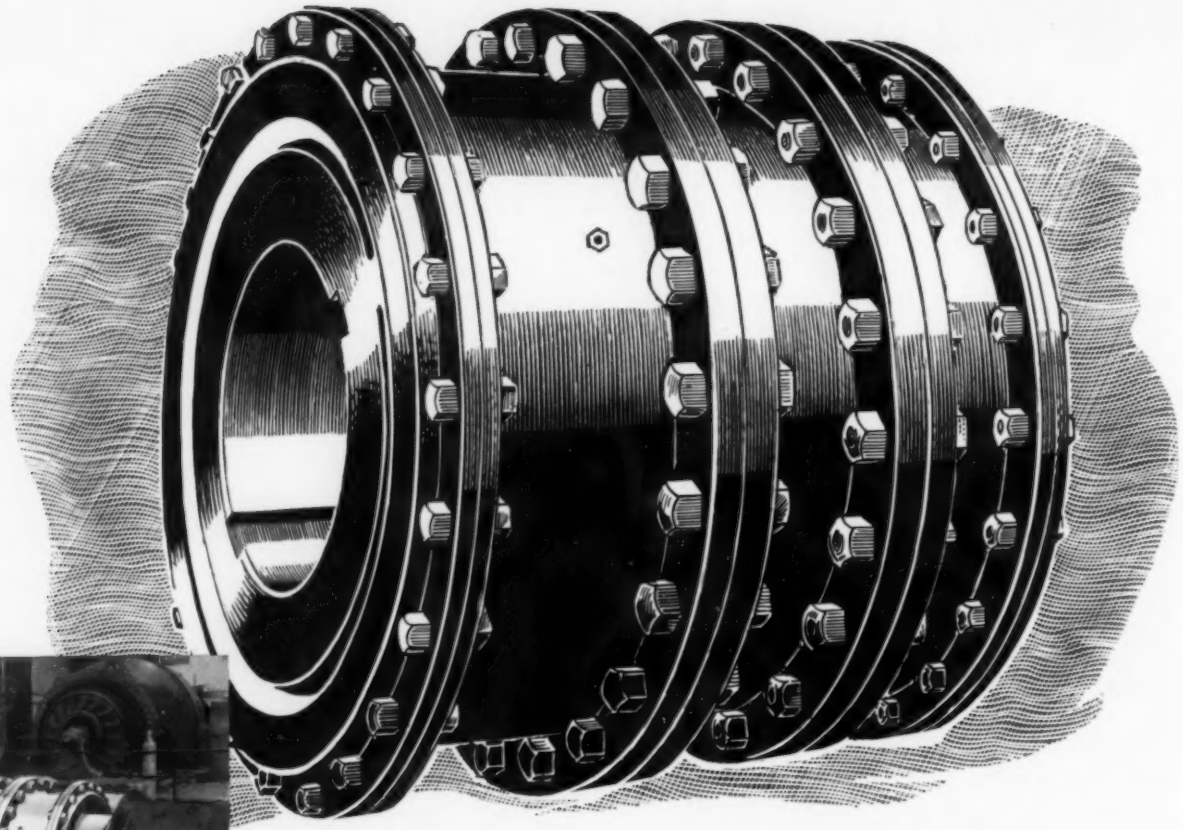
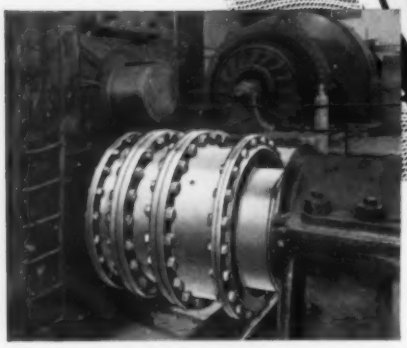
570 Woodward Avenue, Buffalo 17, N. Y.
HYDRAULIC PRESSES • DIE CASTING MACHINES
ROLLING MILL AUXILIARY EQUIPMENT





This 30″ Bore Fast's Coupling is on the main drive of the blooming mill at a large Eastern steel mill . . . one of many Fast's linking power to production at this installation.

For SAVINGS up to $30,000 per hour... FAST'S Couplings are FIRST!

A coupling failure in the steel mill installation shown here would cost this mill $30,000 for every hour of down-time! That a Fast's Coupling was selected for this vital spot is striking testimony to the reputation for rugged dependability Fast's Couplings have enjoyed through the years. And Fast's guarantees *you* the same protection against costly shutdowns, whatever your coupling applications!

Remember: Fast's Couplings give you *rugged construction* . . . the original design has been maintained without basic change or sacrifice in size or materials. Fast's Couplings give you *lowest* cost per year . . . *Fast's usually outlast the equipment they connect.* And Fast's Couplings give you the benefit of Koppers *free engineering service* . . . assuring you of the right coupling for any job and the right solutions to tough coupling problems.

For full details on how Fast's Couplings and Koppers Engineering Service can help you insure uninterrupted power transmission, write today for your free copy of our catalog to: KOPPERS COMPANY, INC., *Fast's Coupling Dept.*, 219 Scott Street, Baltimore 3, Md.

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THE ORIGINAL

FAST'S Couplings

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers-Elex Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus.

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Gentlemen: Send me a Fast's Catalog giving detailed descriptions, engineering drawings, capacity tables and photographs.

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G-E TO BUILD NEW PLANT IN ILLINOIS

▲ A five million dollar General Electric plant will be built at Bloomington, Ill., to manufacture general purpose controls for industrial use, it was announced recently by William C. Wichman, vice president and general manager of the G-E industrial power components division.

Construction of the new facilities will start this year on a 66-acre tract where U. S. Route 66 crosses the Illinois Central Railroad tracks about two miles from the center of Bloomington, Mr. Wichman said.

The new G-E plant will consist of a manufacturing area, including warehouse, laboratory, cafeteria, and personnel facilities, and an attached modern office building. More than two million dollars worth of equipment will be installed in the plant.

PLANS EXPANSION OF RESEARCH PROGRAM

▲ Plans for an expanded research program, including a further addition to its laboratories, have been approved by the board of directors of E. F. Houghton & Co.

An additional floor will be added over the present research laboratory to provide required facilities for the program, and the staff of chemists will be increased. This expansion is particularly aimed at four fields, all of which represent areas of interest consistently covered by this company in past years.

A new approach to the project of cutting fluids for modern machine tools, following up recent Houghton developments. There is an ever increasing responsibility on the cutting fluid, it is pointed out, due to higher machine speeds, new alloys such as nimonic and titanium, and new developments in tooling. Further study of chemical surface treatment of metals, including new developments in phosphating compounds, pickling inhibitors and coloring agents. An expanded heat treatment program, including new furnaces and research on new types of molten salt baths for treating steel and non-ferrous metals. Added emphasis on textile oils and synthetic processing agents for the many new man-made fibers now being perfected.

PICKLING ACID INHIBITOR.....

Trade Mark

RODINE

Reg. U.S. Pat. Off.

"Rodine" more than pays for itself in savings of acid and metal. More uniform pickling and better pickled surfaces are obtained when "Rodine" is used in acid pickling baths.

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Space 1104
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October 19th - 23rd

CHEMICALS ACP PROCESSES

AMERICAN CHEMICAL PAINT COMPANY
General Offices:
AMBLER, PENNSYLVANIA
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Ready-Power offers 4 important advantages

OVER ALL OTHER GAS-ELECTRIC DRIVES

1—ONLY READY-POWER CAN BE QUICKLY CHANGED. A spare can be installed in 5 minutes!

2—ONLY READY-POWER CAN BE SHIFTED FROM ONE TRUCK TO ANOTHER, permitting standardization of power.

3—ONLY WITH READY-POWER CAN YOUR TRUCKS BE KEPT WORKING with a quick change of power units.

4—ONLY READY-POWER OPERATES AT THE LOW ENGINE SPEED that results in long life and low maintenance.

Remember . . . your truck is no better than its power. It PAYS to convert present electric trucks to Ready-Power . . . and it PAYS to specify Ready-Power when buying new trucks.

CONTINUOUS-DUTY POWER UNITS

The READY-POWER Co.

3836 Grand River Ave., Detroit 8, Michigan

Manufacturers of Gas and Diesel Engine-Driven Generators and Air Conditioning Units; Gas and Diesel-Electric Power Units for Industrial Trucks

Construction will begin this Fall, with the hope of starting on this further research program early in 1954. Houghton's present laboratory was built in 1928 and an addition constructed in 1941.

TO CONSTRUCT NEW METALLURGICAL LAB

▲ Radical advances in metals and related products are expected to be hastened by a new metallurgical development laboratory, plans for which were announced by the General Electric Co.

This new facility, a part of the company's multi-million dollar research laboratory at the Knolls near Schenectady, N. Y., will provide more than 70,000 sq ft of floor space, raising the gross area of the laboratory to more than half a million sq ft. It will be the eighth building of those comprising the research laboratory.

Dr. C. G. Suits, vice president and director of research, said that the new structure will provide extensive facilities in which new metallurgical materials developed in the laboratory can be produced in sufficient quantities to enable them to be evaluated by operating components of the company. This pilot-plant stage forms an essential step between research and application, he said.

ANNOUNCE PURCHASE OF VARNISH COMPANY

▲ Purchase of Irvington Varnish and Insulator Co. of Irvington, N. J., by Minnesota Mining and Manufacturing Co. was announced recently.

Herbert P. Buetow, president of Minnesota Mining said that Irvington is to become a division of Minnesota Mining.

Irvington Varnish & Insulator Co. is best known for its wide lines of insulating varnishes, varnished cloths and papers, and extruded plastic insulations. The company's chemical division produces an extensive line of resins most of which are derived from the liquid of the cashew nut shell. These resins also are useful in the electronics field because of their high dielectric strength. In recent years Irvington has gained additional recognition with a line of bottle cap liners.

RECEIVES ORDERS FOR FREIGHT CARS

▲The Erie Railroad Co. has just placed an order for 300 70-ton mill type, steel gondola cars with Greenville Steel Car Co., Greenville, Pa., a subsidiary of Pittsburgh Forgings Co. Building and delivery is scheduled for the first quarter of 1954. The cars are to be 52 ft, 6 in. in side length and are to be duplicates of 500 cars built and placed in service by the Erie in 1952. The Erie's order is supplemented by a recent order for 175 50-ton box cars, 25 of which are 40 ft, 6 in., side length, and the remaining 150 of 50 ft, 6 in., side length. In addition, an order was recently received by Greenville Steel Car Co. from the Baltimore & Ohio Railroad to build 100 70-ton flat car underframes.

WORK SAFETY PROVED BY U. S. STEEL SURVEY

▲ Where is it safer—at work or off the job?

As far as United States Steel Corp. employees are concerned, the answer is "at work" by a three-to-one ratio. The big accident risk begins when they start for home.

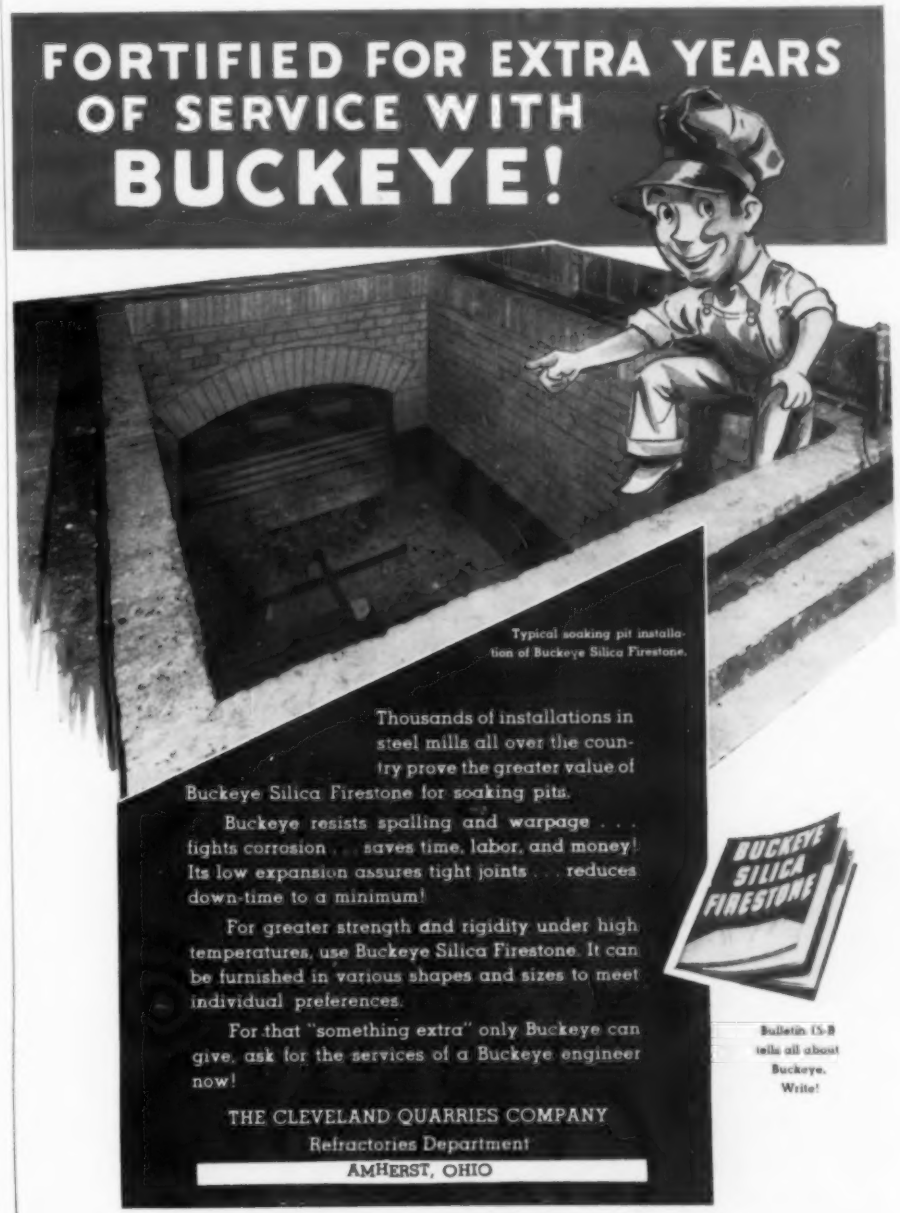
Statistics derived from employee insurance records and disclosed by U. S. Steel's safety department reveal that three times as many lost-time accidents occur to U. S. Steel workers during leisure hours as those which happen on the job.

It might appear from these figures that U. S. Steel employees are having a relatively high off-the-job rate of accidents but this is not the case. Comparison with National Safety Council records show that U. S. Steel's rate is less than half of the national average. Actually, Safety Council statistics for 1952 reveal that for each thousand men in all types of work 45 lost- time accidents occurred off-the-job on a nationwide basis, whereas U. S. Steel's records indicate that men enrolled in its insurance plan had but 17 per thousand.

U. S. Steel safety men believe that this comparison shows that the many hours of safety training in the plants are making steel men safety conscious to the extent that safe habits are being carried into off-the-job living, with a resultant reduction in accidents.

In addition the safety department has inaugurated several programs to help bring safety consciousness to U. S. Steel employees in their activities outside the plants. Among various material distributed have been "Beat the Heat" pamphlets, bumper banners for automobiles, vacation safety posters and advice on diet.

U. S. Steel's accident record is one of the best in all industry and the corporation this year received the Honor Award from the National Safety Council for its record of only 2.17 accidents per million man-hours worked in all steel producing divisions.


FORTIFIED FOR EXTRA YEARS OF SERVICE WITH BUCKEYE!
Typical soaking pit installation of Buckeye Silica Firestone.
Thousands of installations in steel mills all over the country prove the greater value of Buckeye Silica Firestone for soaking pits.
Buckeye resists spalling and warpage . . . fights corrosion . . . saves time, labor, and money! Its low expansion assures tight joints . . . reduces down-time to a minimum!
For greater strength and rigidity under high temperatures, use Buckeye Silica Firestone. It can be furnished in various shapes and sizes to meet individual preferences.
For that "something extra" only Buckeye can give, ask for the services of a Buckeye engineer now!
THE CLEVELAND QUARRIES COMPANY
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BUCKEYE SILICA FIRESTONE
Bulletin 15-B tells all about Buckeye. Write!
BUCKEYE
"FOR THAT EXTRA SERVICE"
SILICA FIRESTONE

OPEN PITTSBURGH DISTRICT WAREHOUSE

▲ A steel warehouse specializing in sales of sheet and strip has been opened in the Lawrenceville district of Pittsburgh, Pa., by the newly-formed Conners Steel Warehouse, Inc.

Installation of equipment, including shears and a crane, has just been completed in the warehouse at 5610 Harrison Street.

The new Connors warehouse will deal exclusively in hot rolled and cold rolled strip and sheet, reflecting the steady growth of the Pittsburgh area as a user of flat rolled steel products.

TO BUILD TITANIUM PLANT IN TENNESSEE

▲ Production of titanium sponge, the almost-pure raw material from which the "wonder metal" is made, will be increased by 6,000 tons a year as result of a contract between Cramet Inc., of Chicago, Ill., and the Defense Materials Procurement Agency, Edmund F. Mansure, Administrator of DMPA, announced.

The contract calls for construction of a 25 million dollar plant. Final selection of the site has not been made, but a location near Nashville, Tenn., is under consideration. Scheduled for partial production by early 1955 and full production a year later, the new plant will include facilities for production of ingots of titanium and titanium alloys as well as sponge.

It will be the biggest titanium operation so far undertaken in the government-industry expansion program.

In all, the contract with Cramet, a wholly owned subsidiary of Crane Co., Chicago, Ill., calls for production of 30,000 tons of titanium sponge over a period of five years. DMPA will advance the company up to $24,950,000 for construction and equipment costs to be repaid with interest as titanium sponge is produced.

NEW CARBON PLANT WILL DOUBLE FACILITIES

▲ Electro-Nite Carbon Co., manufacturers of carbon brushes, bearings, seal rings, and other carbon products, is constructing a new plant at Torresdale Avenue and Strahle Street, northeast Philadelphia, Pa.

Located in Philadelphia since 1920, and at their present location, 1133-41 E. Columbia Avenue, since 1936, the company will more than double its production area and substantially increase its laboratory and testing facilities through this expansion program. Adequate parking space will also be provided on the two acre site of the new plant.

Construction features include the latest industrial lighting and dust collecting systems. Occupancy is expected in the early Fall of this year.

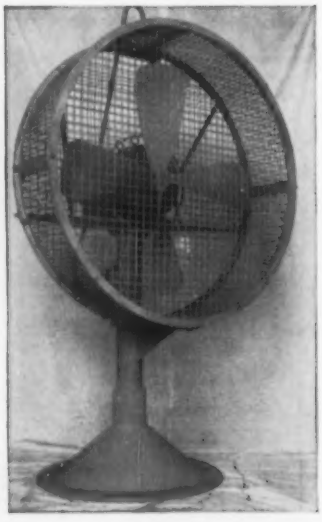
TO HOLD ANNIVERSARY MEETING IN ST. LOUIS

▲ The Gray Iron Founders' Society, Inc., will hold its 25th Silver Anniversary Meeting at the Hotel Jefferson, St. Louis, Mo., on October 8 and 9. Early arrivals will attend the presidents' reception and dinner scheduled for the evening of October 7. Past society presidents will be honored at that time.

IS HEAT SLOWING UP YOUR WORKMEN?

TRUFLO CRANE CAB FANS
For cooling interiors of crane cabs and other confined areas. Adjustable both horizontally and vertically. Four blade type, 12 and 18 in. sizes.

Keep them COOL with TRUFLO FANS



TRUFLO PORTABLE COOLING FANS
Easily portable. Help keep efficiency high where work is hottest. 12 to 36 inch diameters.

Production suffers when workmen are overheated. Steps begin to drag, efficiency falls.

Now, when speedy production is vital, Truflo Fans can help keep your workmen on their toes. All Truflo Fans are designed and built correctly to put fresh cool air *in large volumes* exactly where it is needed. Perfectly-balanced shafts and blades give more air per h.p. . . . strong steel frames stand up longer under hard use . . . rugged wire guards protect men against injuries.

All of the following types can help beat the heat, keep production moving in your plant. Write for illustrated literature.

PORTABLE COOLING FANS
CRANE CAB FANS • WALL FANS
EXHAUST FANS • BLOWERS
ROOF VENTILATING FANS
PENT HOUSE FANS

TRUFLO FAN COMPANY
245 MAIN ST. HARMONY, PA.

Here's why you save time and money
WITH FARREL® ROLL GRINDERS

These machines are extremely fast for either heavy roughing or producing as high a mirror finish as it is possible to obtain with wheels at present available. They grind straight, convex or concave rolls.

The crowning device produces a mathematically accurate curve, symmetrical on both halves of the roll, for either a convex or concave shape. It is easily and quickly set and requires no manipulation during operation. The same setting invariably produces exactly the same curvature and permits fixed, uniform and easily controlled accuracy of contour in all rolls.

Farrel roll grinders are available in two types and nine standard sizes. Write for descriptive bulletins.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.

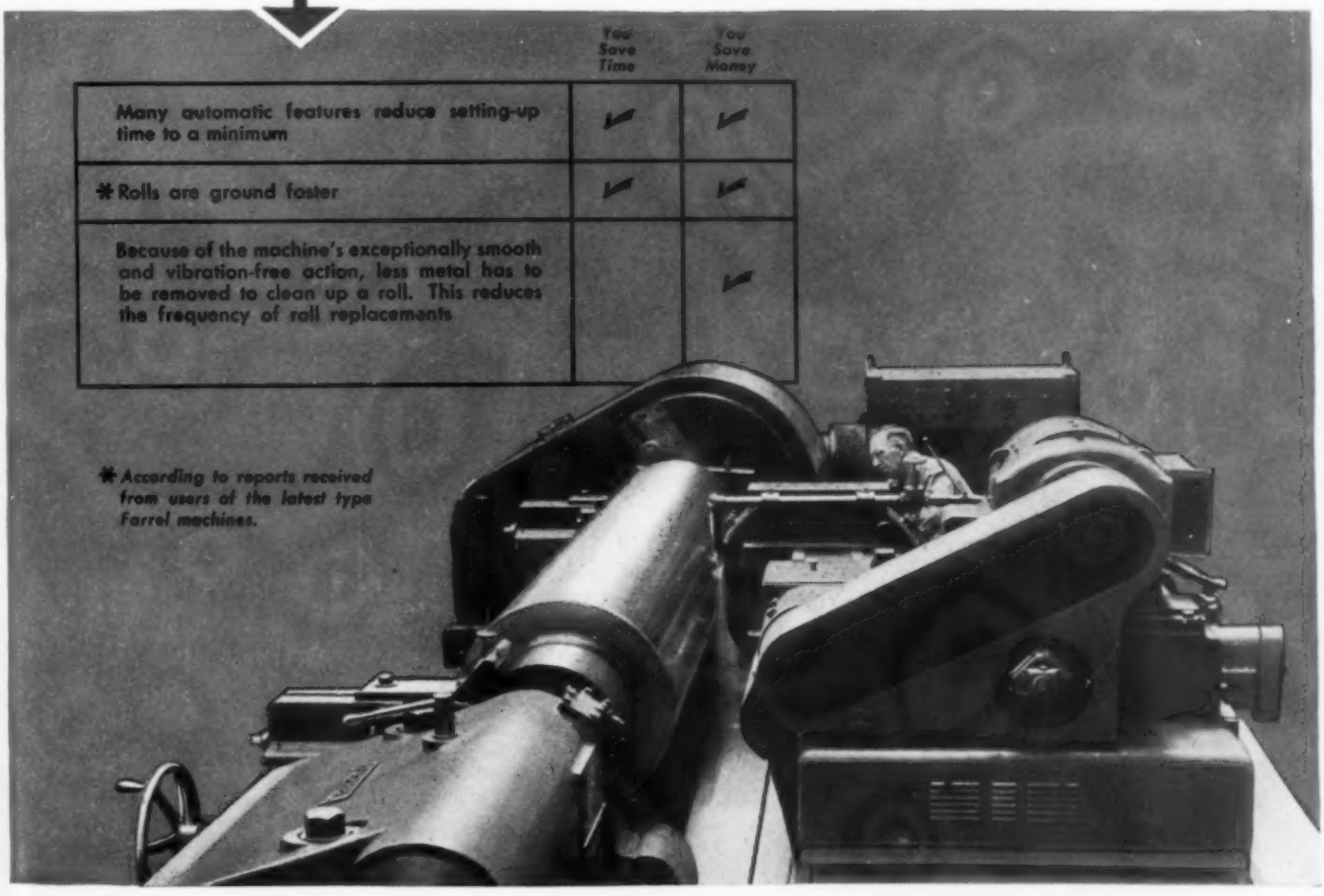
Plants: Ansonia and Derby, Conn., Buffalo, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Akron, Chicago, Los Angeles, Houston

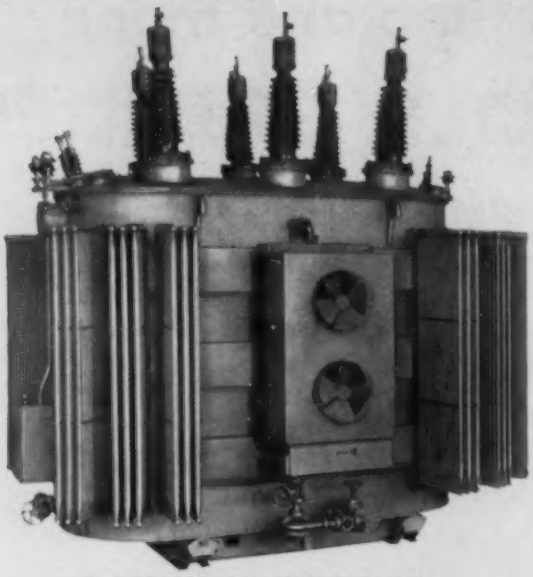
Farrel-Birmingham®

FB-799

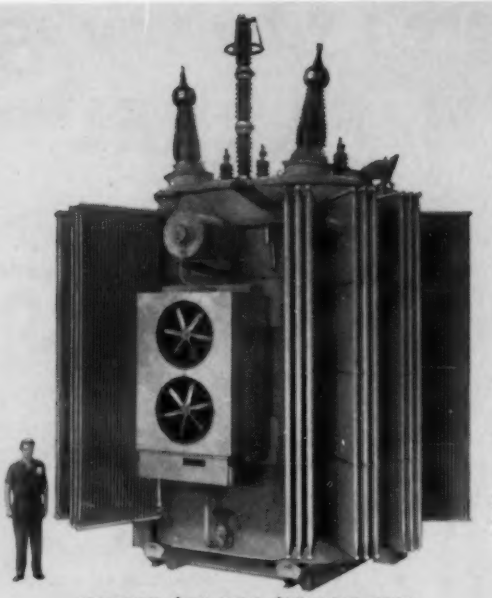
	You Save Time	You Save Money
Many automatic features reduce setting-up time to a minimum	✓	✓
*Rolls are ground faster	✓	✓
Because of the machine's exceptionally smooth and vibration-free action, less metal has to be removed to clean up a roll. This reduces the frequency of roll replacements		✓

*According to reports received from users of the latest type Farrel machines.



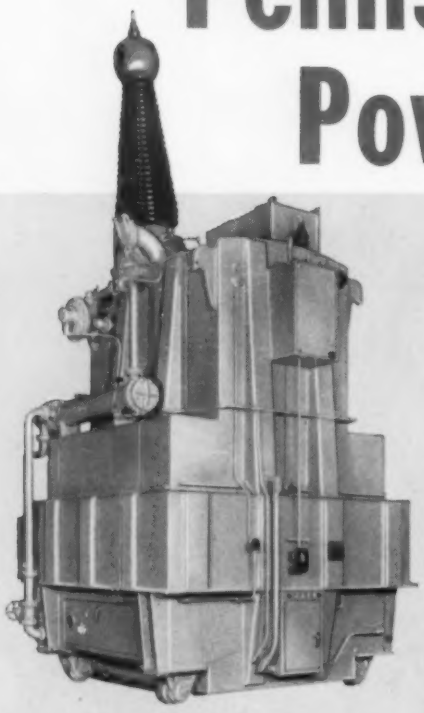


36,000/48,000/60,000 KVA
Auto Transformer. Three-phase, 60 Cycles, 55°C. Rise. 138,000 Grd. Y —115,000 Grd. Y—13,800△ volts.



25,000/33,333/41,667 KVA
Single-phase, 60 Cycles, 55°C. Rise. 110,000—7950/13,800 volts.

Pennsylvania Oil-filled Power Transformers



29,000 KVA
Single-phase, 60 Cycles, 55°C. Rise. 230,000 Grd. Y/132,800 —13,200 volts.

According to NEMA Standards, oil-filled transformers can be cooled in nine different ways. The manner of cooling depends upon many considerations, such as the operating characteristics of transformers using various types of cooling; the availability of large quantities of water; and what is very important, the economics of selecting one type of transformer over another.

The latter consideration may require some study. Auxiliary cooling methods applied to a self-cooled transformer can add, at relatively low cost, as much as 66⅔% additional capacity to the transformer. On the other hand, the efficiency of the transformer and the cost of operating certain types of cooling equipment may be more important considerations than the initial lower cost of a forced-cooled transformer. These are matters that can best be discussed between the engineers who specify a transformer and the engineers who design the transformer.

Pennsylvania Transformer Company manufactures transformers of every standard classification and with every type of cooling equipment. If you have a problem in cooling, or for that matter, if you have any transformer problem, you are invited to utilize the experience of Pennsylvania's Engineering Department.

Write for free copy of booklet No. 522 entitled "Economics of Transformer Cooling." This booklet explains the various methods of cooling transformers and discusses their advantages and disadvantages.

PENNSYLVANIA TRANSFORMER COMPANY
A McGRAW ELECTRIC COMPANY DIVISION
CANONSBURG, PA. • *Greater Pittsburgh District*

TRANTINYL

Tube Mill Rolls and Plugs

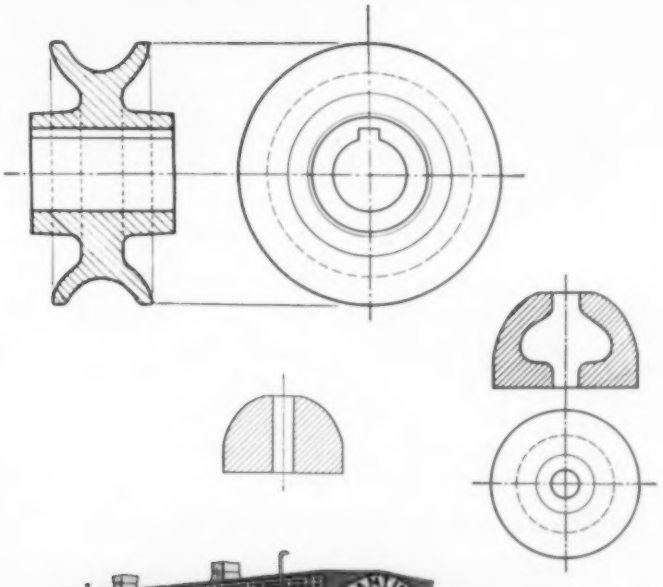
for "remarkable performance"

...SAY TUBE MILL MEN

"The Youngstown Alloy Casting Corp. also manufactures PIERCER POINTS and ROLLING MILL PLUGS under the name "Trantinyl", and both of them are very high quality products. For instance, on rolling mill plugs, we have had as many as 5800 hot billet passes rolled over one single plug, which is very remarkable performance."

"From time to time we have tried out samples from other manufacturers, but the performance of the "Trantinyl" is so superior that there is no comparison."

"We feel rather kindly toward Youngstown Alloy Casting Corporation because of the quality of the products they have furnished us, which have contributed much toward our success in overcoming mill delays, and toward our success in manufacturing Seamless Tubing of a very high quality."



"TRANTINYL GUIDES THE STEEL INDUSTRY"

SEAMLESS TUBE MILLS:
guide shoes, rolling mill plugs and rolls, piercer points, etc.

ELECTRIC WELD TUBE MILL:
forming rolls, planishing rolls, tool holders, etc.

ROLLING MILLS:
bar, hoop, strip, shape mill guides; and rollers

STRAIGHTENING MACHINE GUIDES • HEAT RESISTING CASTINGS

"TRANTINYL No. 1" CAST TO SHAPE

T-2

Youngstown Alloy Casting Corp.
Youngstown, Ohio

You can maintain more of the FULL-RATED PRESSURE

with ZURN Engineered Low Pressure Drop LPD STRAINERS

Plug Relieving Yoke assures easy valve operation since the plug can be unseated before turning.
"C" washer and yoke cover closures facilitate rapid cover removal for cleaning.
Minimum open area ratio of 6 to 1 maintained even though selected basket material may be only 30% open.
Eccentric location of baskets creates a flow cross-section proportional to the flow at all points in the screen cavity, thus reducing turbulence and flow resistance at that critical point.
Zurn LPD Duplex Plug Type Strainers permit high rates of flow with remarkably low pressure drop and immeasurably improve the handling of fluids such as oil, chemicals, water through pipe lines.

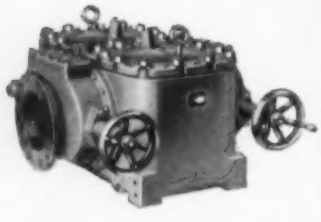
Zurn Low Pressure Drop (LPD) Strainers are design improved for correct circularity. They have ample waterways; smooth inner walls; correctly sized and perforated baskets, eccentrically positioned, all of which combine to reduce pressure loss and afford maximum protection for all types of mechanical units connected with pipe lines. Zurn LPD Strainers are held to close tolerances for materials, shapes, and dimensions, assuring the utmost in strength and safety and continuous operation.

Zurn LPD Strainers are widely used to protect close-tolerance control devices and delicate mechanisms, also to protect product purity. They make continuous production processes possible.

Zurn LPD Strainer applications include fluid handling lines for lubricating and fuel oil, and oil during the refining process; a wide range of chemicals produced and used by the various process industries; public utility power plants; power stations; industrial plants; ships and high-temperature installations. Zurn Fluid Handling Engineers are available for consultation on your particular problem.

J. A. ZURN MFG. CO.
INDUSTRIAL DIVISION
ERIE, PA., U.S.A.
In Canada: Canadian Zurn Engineering Ltd., Montreal 25, P. Q., Canada

There is a ZURN LPD strainer for every fluid handling purpose



Zurn Duplex Gate Type Multi-Basket Strainer.

Zurn Sinlex Strainer. Available in offset and straight-through types.

Zurn "Y" Type Strainers available in any cast material and for high pressures.

Zurn Duplex Plug Type Strainer.

Zurn Engineered Low Pressure Drop Strainers are patented and patents pending.

WRITE FOR LPD STRAINER MANUAL DATA NO. 952

This manual includes previously unpublished pressure drop data and gives useful, factual information on fluid handling.

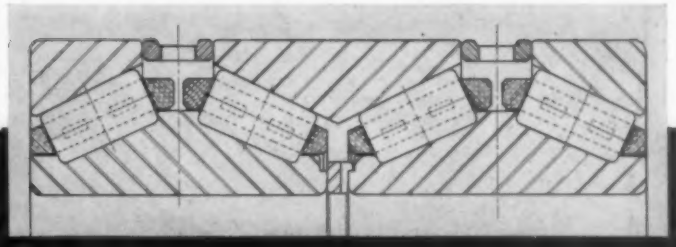
Copyright 1953

J. A. ZURN MFG. CO.
Industrial Division, Erie, Pa., U. S. A.
Please send me Zurn LPD Strainer Manual Data No. 952.

Name _____
Position _____
Company _____
Street _____
City and State _____

Please attach coupon to your business letterhead—Department ISE

TORRINGTON Four-Row Tapered Roller Bearings on finishing-stand work-rolls of U. S. Steel 80″ hot-strip mill were specially designed for high thrust loads.



Rolling to a new

world's record!

2,621,500 net tons of 2000-foot coils of uniform strip! That was the world's record rolled in 1951 by U. S. Steel's 80″ hot-strip mill—on TORRINGTON Tapered Roller Bearings.

Precision-ground TORRINGTON Tapered Roller Bearings are used on many of the work-roll and back-up thrust positions, from the huge mill's No. 1 scale breaker to its finishing stands.

These TORRINGTON Bearings, say U. S. Steel engineers, have given excellent service. Specially designed by TORRINGTON to withstand the high thrust loads developed, they have helped to cut down-time to only one hour a turn.

Get more tons per turn from *your* mills. Equip them with TORRINGTON Tapered Roller Bearings.

THE TORRINGTON COMPANY

South Bend 21, Ind. Torrington, Conn.

TORRINGTON TAPERED ROLLER **BEARINGS**

Spherical Roller • Needle • Tapered Roller • Straight Roller • Ball • Needle Rollers

Keep NATIONAL Carbon Brick on hand for MAINTENANCE

TRADE-MARK

KEEP THESE STANDARD SIZES ON HAND FOR EMERGENCY!

13½" x 6" x 3" series
9" x 6" x 3" series
9" x 4½" x 2½" series

☆

Write for Catalog Section S-6210

If you think of carbon only in terms of complete furnace linings, check these other important locations in and around the furnace where "National" carbon brick and shapes will also save time and money as a maintenance refractory:

- ✓ **RUNOUT TROUGHS**
- ✓ **CINDER NOTCH LINERS**
- ✓ **CINDER NOTCH PLUGS**
- ✓ **SPLASH PLATES**
- ✓ **SKIMMER PLATES**

...and Many More!

The term "National" is a registered trade-mark of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY

A Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y.

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

In Canada: National Carbon Limited, Montreal, Toronto, Winnipeg

Personnel News...

S. M. Jenks has been appointed to the newly-created post of assistant executive vice president—operations, United States Steel Corp., Pittsburgh, Pa. At the same time, **John H. Elliott** has been appointed vice president, operations—steel, succeeding Mr. Jenks and **E. H. Gott** has been made general manager, operations—steel, succeeding Mr. Elliott. Mr. Jenks has been vice president, operations—steel, since January, 1950. He has been associated with United States Steel since 1925, when he began his first job at the American Sheet & Tin Plate Co. as an engineer. Mr. Jenks held various positions in the engineering department until 1935, when he was appointed chief engineer of the former Carnegie-Illinois Steel Corp. In 1940, he was named general superintendent of the Gary works, Gary, Ind., and on April 1, 1949, became manager of operations, Chicago district. He held this position until his appointment to the position of vice president, operations—steel in 1950. Mr. Elliott started with United States Steel Corp. in 1919, when he became connected with the engineering department of American Sheet & Tin Plate Co. He advanced through various positions in the engineering departments at several U. S. Steel plants until 1940, when he was made assistant general superintendent, Irvin works. In 1947, he was named general superintendent, and in 1950 was appointed assistant general manager of operations. He held this position until 1951, when he was appointed general manager, operations—steel. Mr. Gott has been general superintendent of U. S. Steel's Youngstown district operations since March, 1951. He first started with United States Steel in 1937 at Youngstown, Ohio, district works. He served several years at Clairton, Pa., works and in 1941 was transferred to the Gary, Ind., steel works as plant industrial engineer. At Gary, after promotion through several jobs, he was named assistant general superintendent of the service department and in 1951 was made assistant general superintendent at the South works in Chicago. Mr. Gott held this position until his appointment in 1951 as general superintendent at Youngstown.

William H. Yeckley has been appointed to a new position of general manager of steel operations for Youngstown Sheet and Tube Co., Youngstown, Ohio. For the last three years Mr. Yeckley has been assistant to the vice president in charge of operations. He has been directing steel operations in both the Youngstown and Chicago, Ill., districts.

Charles E. Greenlee has been named assistant to the vice president of sales at Basic Refractories, Inc. For the past three years, Mr. Greenlee has specialized in mineralogical studies of dead burned dolomite, dead burned magnesite and other granular-type refractories produced by the company.

Waldo W. Smith was appointed general manager of Tower Iron Works, Providence, R. I., succeeding the late **Howard R. Chase.** Mr. Smith has been connected with Tower Iron Works since 1939 serving as chief engineer since 1947.

James M. Quarry was named assistant superintendent of the plate mills of Lukens Steel Co., Coatesville, Pa., advancing from supervisor of the 140-206 mill. **Robert C. McMichael** takes over in the 140-206 mill. **Oscar E. Jackson,** will replace Mr. McMichael as supervisor of the 120 mill. In the metallurgical department **Harold A. Grubb** was named assistant metallurgical engineer in the plant. **Samuel D. Lemmon's** new title is assistant metallurgical engineer, service. Other metallurgical department changes include **Paul R. Chandler** from assistant engineer of tests to engineer of tests, and **Charles F. Wilson** from chief observer to assistant engineer of tests. In another promotion, **George L. Stroman** was advanced from assistant to the superintendent of the miscellaneous finishing department to supervisor of the same department.

Donald S. McCleary has been named district purchasing agent by Continental Foundry & Machine Co., Pittsburgh, Pa., succeeding E. M. McNally who died recently. Mr. McCleary was with the engineering and, later, purchasing department of United States Steel Corp. from 1925 until he joined Continental as a buyer last year.

S. M. JENKS

JOHN H. ELLIOTT

E. H. GOTT

WILLIAM H. YECKLEY

Merrick Lewis, has been elected president of Alliance Machine Co., Alliance, Ohio. Mr. Lewis succeeds **H. A. Fennerty,** who now becomes board

MERRICK LEWIS

chairman. Mr. Lewis is also vice president of the Lewis Engineering & Manufacturing Co.

Raymond A. Frick has been appointed vice president of the Brake Shoe & Castings Division of American Brake Shoe Co. Formerly general works manager of the division, he joined the company as a special apprentice in 1942. He has held various operating and administrative positions in several plants of the division and at New York headquarters. He will continue to be located at the company headquarters in New York.

P. L. Coddington has been appointed assistant to the president of Carpenter Steel Co. at the firm's Alloy Tube division, Union, N. J. Mr. Coddington had been manager of sales at the tube division since 1945.

Edgar B. Speer was appointed assistant general superintendent of the Duquesne, Pa., works of U. S.

EDGAR B. SPEER

Steel Corp. Mr. Speer has been serving as division superintendent of steel production at Gary, Ind., works.

F. S. Speicher, Jr., has been elected president and treasurer of M. E. Cunningham Co., Pittsburgh, Pa.; **F. S. Speicher, Sr.,** was elected vice president in charge of research and development; **Walter J. Speicher,** vice president in charge of sales and secretary; **William G. Kratz,** vice president in charge of production. In addition, **Edwin W. Speicher** has been elected assistant vice president, **Viola Stewart** elected assistant secretary, and **Leon C. Hauer** appointed chief engineer, in charge of product designing. Previously F. S. Speicher, Jr. had been secretary and treasurer, while F. S. Speicher, Sr. had served as president. Walter Speicher formerly was assistant treasurer and William Kratz was shop superintendent.

Eugene J. Lenar, formerly with Western Michigan Steel Foundry, Muskegon, Mich., joined the Carboloy department of General Electric Co. as an engineer in the metallurgical process and quality control unit for permanent magnet materials at the Edmore, Mich., plant.

Judson Neff has been named manager of all manufacturing and production operations in the Pittsburgh and Midland, Pa. plants, as well as manager of the

JUDSON NEFF

engineering and estimating departments, of Mackintosh-Hemphill Co. Mr. Neff goes to Mackintosh-Hemphill Co. with a diversified background in production management and engineering.

Arthur L. Foltz, Jr. has been named manager of the Detroit, Mich., district office of DeLaval Steam Turbine Co. Mr. Foltz brings to his new position 12 years of experience, including four years in the Detroit area, in engineering and sales of steam turbines, pumps and blowers for the Allis-Chalmers Manufacturing Co.

Clinton H. Johnson was named sales engineer in the electrostatic precipitator department of Koppers Co., Inc., Pittsburgh, Pa. Mr. Johnson joined Koppers in 1951 as a test engineer and has worked extensively on field testing of precipitators for fly ash, black liquor, blast furnace, and detarrer installations.

Thomas R. Harden has joined L. J. Wing Mfg. Co., Linden, N. J. as a mechanical engineer in the heating

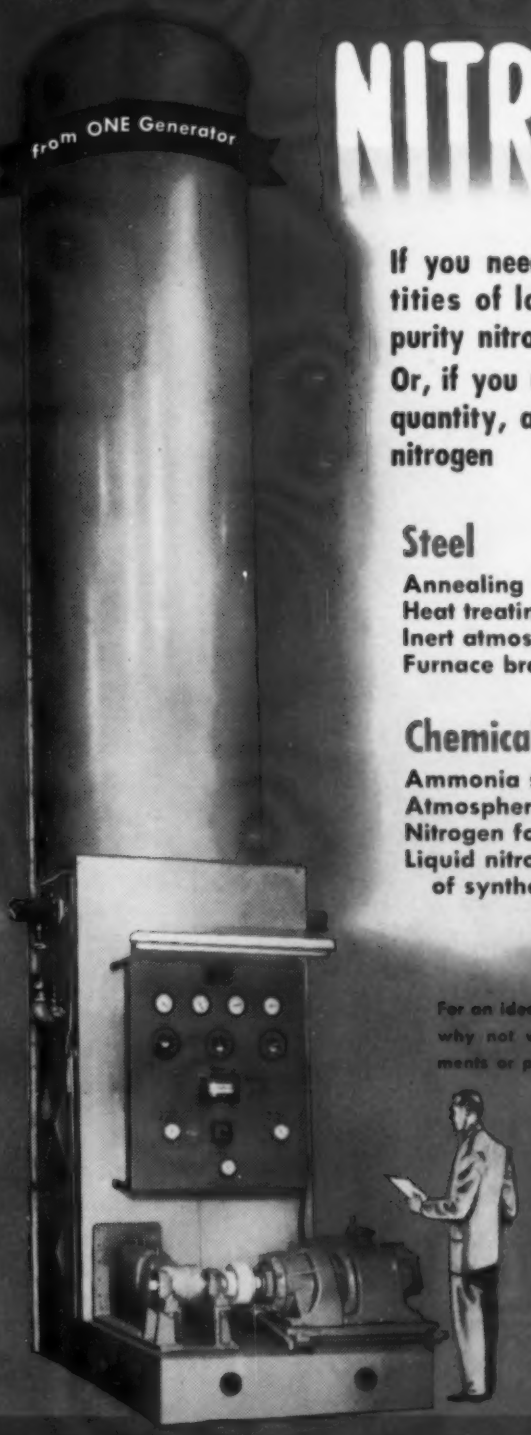
When does it pay to "make your own"?

OXYGEN

In general, if you use from 300,000 cubic feet per month to 500 tons (or more!) per day

Steel
Decarburization
Furnace enrichment
Scarfing
Welding and cutting

Chemical
Production of synthesis gas for
Ammonia
Acetylene
Methanol, Etc.



NITROGEN

If you need large quantities of low-cost, high-purity nitrogen—
Or, if you use oxygen in quantity, and also need nitrogen

Steel
Annealing
Heat treating
Inert atmospheres
Furnace brazing

Chemical
Ammonia synthesis
Atmosphere control
Nitrogen for drug making
Liquid nitrogen scrubbing of synthesis gas

Whatever your requirements, check with us! We'll be glad to talk over your needs . . . help you decide if "making your own" would be advantageous.

Possibly one of our 14 standard *High-Purity* Oxygen-Nitrogen Generator models would satisfy your requirements. Or, perhaps your interests would indicate an Air Products *Tonnage* Oxygen-Nitrogen plant — available in 9 standard models, or built to meet particular needs.

For an idea of what we can do for you, why not write us about your requirements or problem? We'll send back our NEW CATALOG, *plus* an outline of what we've done on needs like yours.

Air Products, Incorporated
Dept. P, Box 538
Allentown, Pa.

Air Products INCORPORATED
High-Purity and Tonnage
OXYGEN-NITROGEN GENERATORS

Specialists in Equipment for All Low-Temperature Processes

and ventilating sales department. Mr. Harden has recently been associated with the Aluminum Co. of America.

Arnold J. Beyer has been appointed division superintendent of power and fuel at Gary, Ind., steel works of United States Steel Corp. Mr. Beyer, who has been

ARNOLD J. BEYER

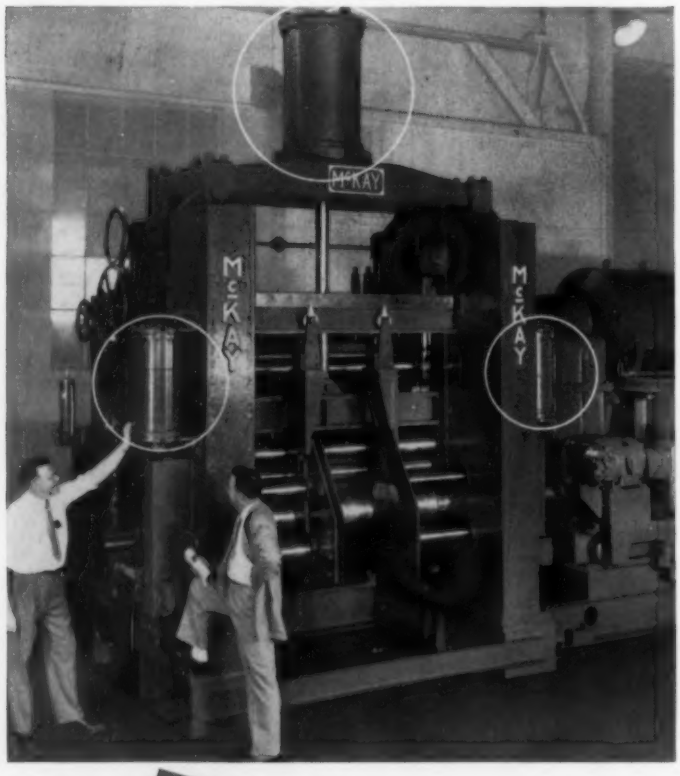
assistant chief engineer at Gary works since 1950, will be succeeded in that position by **Raymond N. Ali,** formerly assistant chief engineer at Clairton, Pa., works of U. S. Steel.

R. V. Robison, who has been associated with their Pittsburgh, Pa., office of Dingle-Clark Co. as a sales engineer for nine years, has been transferred to Cleveland, Ohio, where he will be manager of the machinery division of the Cleveland territory. Prior to joining the Pittsburgh office of Dingle-Clark in 1944, Mr. Robison spent two years as a sales correspondent for Cleveland

R. V. ROBISON

Worm & Gear Co., where he also completed his sales engineering training. Replacing Mr. Robison in the Pittsburgh office will be **L. B. Abrams, Jr.,** who will

(*Please turn to page 277*)



INFORMATION *on the complete line of Anker-Holth products is given in this bulletin. Free on request.*

Help yourself to this "CYLINDER KNOW-HOW"

ENGINEERS of the Steel Industry find it helpful to call in Anker-Holth engineers on power motion problems. Push, pull, lift or lowering action . . . air or hydraulic power . . . regardless of your problem, feel free to ask for the competent help of the nearby Anker-Holth man!

Specify Anker-Holth cylinders. There is a wide range to meet your specific needs, including heavy-duty types for steel mill equipment such as shown here. Write for bulletin. Anker-Holth Division of The Wellman Engineering Company, 2723 Conner St., Dept. E-4, Port Huron, Mich.

Anker-Holth
ENGINEERED CYLINDER POWER
WELLMAN

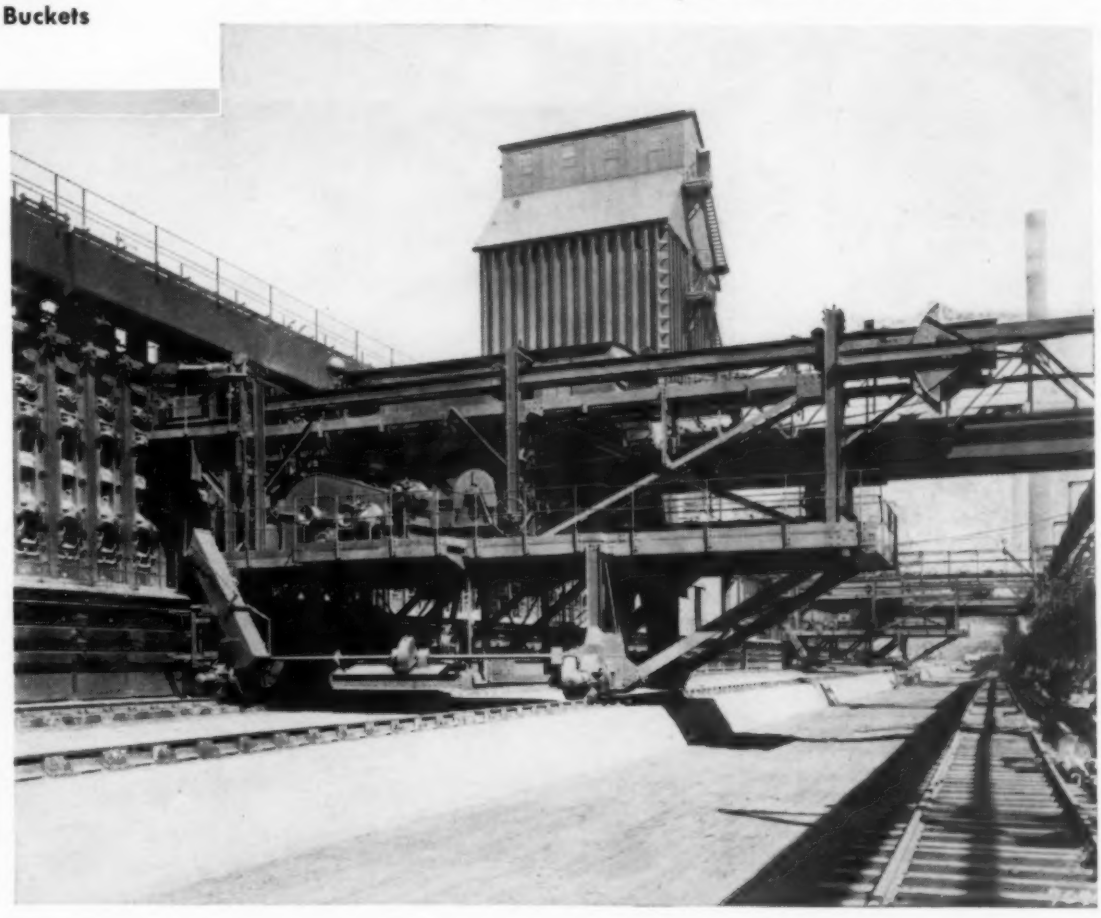
Division of
THE WELLMAN ENGINEERING COMPANY

Wellman will build it

Special Cranes
Coke Pushers
Gas Producer Plants
Ore Bridges
Charging Machines
Forging Manipulators
Gas Flue Systems
Gas Reversing Valves
Mine Hoists
Skip Hoists
Clamshell Buckets

→ Wellman coke pushers

...engineered for economical, trouble-free performance



Wellman Combined Coke Pusher, Coal Leveler and Door Extractor in operation at Bethlehem Steel's Lackawanna Plant.

● Many of the world's most modern byproduct coke oven plants are Wellman equipped. The Wellman Engineering Company's more than half-century experience in building heavy machinery guarantees sound design and expert construction. Wellman equipment provides peak economy, maximum safety and trouble-free performance under a wide variety of operating conditions.

THE WELLMAN ENGINEERING COMPANY

7000 CENTRAL AVENUE · CLEVELAND 4, OHIO

1803

. . . Perry Used It In 1812

The American solid shot that raked and scattered and sunk the British ships in the Battle of Lake Erie were cast by a parent of the Mackintosh-Hemphill Company. ¶One of these cannon balls is still retained. Tests have shown it to be solid throughout. *Today's standard casting practice could not duplicate it.* Mackintosh-Hemphill *experience* of 122 years ago, still carries a profitable lesson. ¶Just as this *experience* helped to write political history, so has it aided in making history in industry. ¶It has solved, in its 131 years of existence, hundreds of difficult metals-industry problems. Much of the machinery in common use is practical evidence of such successful solutions. ¶Today, Mackintosh-Hemphill is assisting the metals industry with equal effectiveness. Its *experience* is at *your* call . . . *experience* that can translate itself into new methods, new machinery for all departments of steel and non-ferrous processing and finishing. We ask the opportunity to work with you.

MACKINTOSH HEMPHILL
PITTSBURGH

How M-H Experience Can Be Put To Work For You

Mackintosh-Hemphill has available a means of cutting sheet mill investment per ton capacity squarely in half . . . and at the same time permitting economical operation on partial production schedules.

This advertisement appears in November, 1934, issue of Fortune

The above copy and illustration which appeared almost two decades ago, still outlines the Mack-Hemp story.

1953

Mack-Hemp's

one hundred fifty years of service to the metals industry

Know-how and experience—one hundred-fifty years of it—are in Mack-Hemp Rolls *with the striped red wabblers.* The *know-how* comes from doing, the *experience* from service to, and cooperation from, our friends in the metal-forming industries.

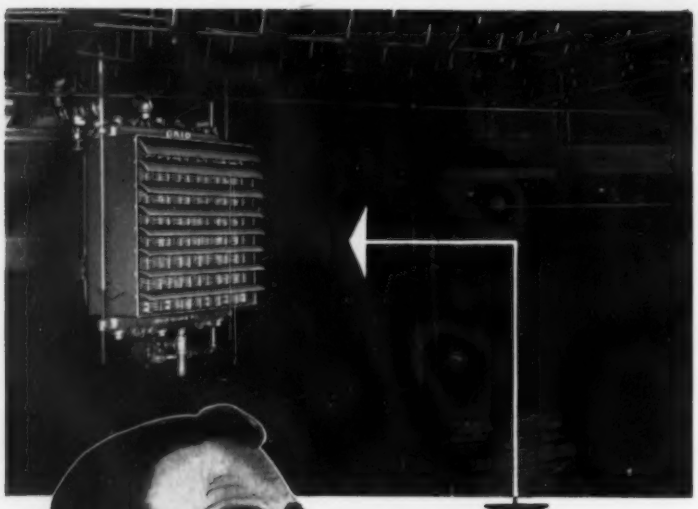
The country was young, and so was the M-H parent company when it cast cannon balls for Perry. But the pioneering zeal and ability to serve has grown with time. Check the complete line of M-H rolls with us. We'll be glad to discuss your rolling mill problems.

MACKINTOSH-HEMPHILL
COMPANY
Makers of the Rolls with the Striped Red Wabblers
PITTSBURGH AND MIDLAND, PA.

MACKINTOSH-HEMPHILL PRODUCTS INCLUDE: rolls . . . levellers . . . steel and special alloy castings . . . completely integrated strip mills . . . heavy duty engine lathes . . . Mackintosh-Hemphill rotary straighteners . . . shears . . . improved Johnston patented corrugated cinder pots and slag handling equipment . . . shape straighteners . . . end-thrust bearings

MACKINTOSH-HEMPHILL COMPANY · PITTSBURGH U.S.A.

THE METALLURGICAL PROPERTIES OF ALL M-H ROLLS ARE CAREFULLY CONTROLLED FOR MAXIMUM SERVICE



Put up to Stay up!

trouble free service for over 22 years...that's only one record for...

GRID UNIT HEATERS

That's the experience of a midwest steel mill who tell us: "We have in service GRID Unit Heaters Type No. 2500. A number have been in use for approximately 22 years on very severe service with steam turned on and off rapidly several times each day. Even under this severe service we have found them maintenance-free." There's the word of a mill operator who has proved that, with a GRID installation, first cost is last cost. Such service records (GRID installations made in 1929 are still operating) are the rule rather than the exception with GRID Unit Heaters because . . .

GRID is an all cast unit with finned heating sections and headers tested to withstand steam pressures up to 250# P.S.I.

GRID construction uses no brazed, soldered, rolled or welded connections between condenser and headers. A specially designed threaded nipple assures a precision, leak-proof fit.

GRID construction has all similar metals in contact with steam, thus preventing electrolytic corrosion which eventually occurs in copper type unit heaters where steam passes from iron pipes into copper cores. (Write for booklet CORROSION IN UNIT HEATERS.)

GRID construction resists corrosion from fumes present in most types of industry.

GRID design incorporating low outlet temperatures, proper fan sizes and motor speeds, assures delivery of warm comfortable air in ample volume to the working level. No stratification of warm air at the ceiling to waste your fuel dollars.

Eastern Stainless Steel Corp. uses GRID BLAST COILS for sheet drying. Write for Catalog BC-1049.

These are the reasons why steel mill operators get 22 years and more of trouble-free service. There are units cheaper than GRID, but there is none better. You start saving money the day you install GRID UNIT HEATERS. Get the complete GRID story. Write for catalog CUH-846-A.

REPRESENTATIVES IN ALL PRINCIPAL CITIES

D. J. MURRAY MANUFACTURING CO.
MANUFACTURERS SINCE 1883 WAUSAU WIS.

---

15 YEARS WITHOUT A BREAKDOWN!

You Can Have This Record Too!

TYPE 242

• This remarkable record of continuous service for FLOWER Brush Holders was made under the most severe operating conditions at one of the largest steel mills in the country (name on request).

FLOWER Job-Designed Brush Holders are available in more than 1000 types and are individually designed for special applications.

Write for Free Catalogue No. 41

FLOWER PHILADELPHIA SINCE 1909

D. B. FLOWER MANUFACTURING CO.
1217 SPRING GARDEN ST., PHILA. 23, PA.
Pittsburgh • Cleveland • Chicago • Detroit • St. Louis • Princeton, W. Va. • Los Angeles

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(*Continued from page 272*)

handle machinery sales in the Pittsburgh district. Mr. Abrams joined Ingersoll-Rand Co.'s New York Engineering office.

Wilbur L. Lohrentz and **Edward C. Myers** were named assistant vice presidents in the industrial relations department of U. S. Steel Corp., Pittsburgh, Pa. **J. Warren Shaver,** previously appointed to a comparable position, will continue as assistant vice president and provide counsel and direction on matters pertaining to labor relations. In the two newly created positions, Mr. Lohrentz will also provide counsel and direction on matters pertaining to labor relations and Mr. Myers on matters pertaining to personnel.

Clydus F. Sells was named superintendent of industrial relations of the Warren, Ohio, district steel plants of Republic Steel Corp. Mr. Sells is presently

CLYDUS F. SELLS

assistant superintendent of industrial relations of Republic's Cleveland district and he succeeds **George H. McClain** who is retiring.

Kennametal Inc., Latrobe, Pa. announces the appointments of **Robert P. Schwing** and **Edward R. Willerton** as representatives, and **William H. Hiltebeitel** and **Samuel H. Jones** as service engineers in the Middle Atlantic district. **Louis Lekich** has been appointed service engineer in the Central district. **Richard W. Phelps** will become service engineer in the Milwaukee district.

Austin Goodyear, general manager of the rubber and conveyors divisions of Hewitt-Robins, Inc., Stamford, Conn. has been elected a vice president of the company.

J. A. Brady was named manager of the lubrication department in charge of sales and application for Penn Petroleum Corp. Mr. Brady was formerly with Penola Oil Co., Detroit, Mich.

Laurin D. Woodworth was named general superintendent and **Oscar Pearson** as assistant general superintendent, at the Youngstown district works, United States Steel Corp. Mr. Woodworth has served his entire employment with U. S. Steel at the Youngstown operations, where be began in 1927 as a chemist. He was named chief metallurgist at the Youngstown plant in 1937, and in 1943 was transferred to the open

LAURIN D. WOODWORTH

hearth department as assistant superintendent. On July 15, 1948, he was made superintendent of the open hearth shop and on September 1, 1949, was appointed division superintendent in charge of steel production. He held this position until 1951 when he was appointed assistant general superintendent of the plant. Mr.

OSCAR PEARSON

Pearson joined U. S. Steel in 1928 as a chemist for the Tennessee Coal & Iron division. Transferring to Gary works in 1941 as assistant to the chief metallurgist, he was later advanced to chief metallurgist. He was appointed division superintendent of steel production at Gary in 1950 and last October was named assistant general superintendent at U. S. Steel's Duquesne, Pa., works.

Bernard A. Shrive, formerly assistant superintendent of electrical maintenance at Kaiser Steel Corp., Fontana, Calif. was named superintendent of that department. Mr. Shrive is a veteran in the industry, having spent 31 years with the Steel Co. of Canada from 1915 to 1946, where he rose from helper to assistant

electrical superintendent. In 1947-48, he served as electrical superintendent with the Coke Oven division of the Allied Chemical and Dye Corp. at Wilputte, N. Y. He was plant engineer for the Kaiser Motors Parts Corp. at Provo, Utah in 1948-49.

John H. Harper was named chief staff engineer for Acme Steel Co.'s Riverdale, Ill., plant. Mr. Harper for

JOHN H. HARPER

the past four years has served as assistant chief engineer in the machine design engineering department.

Garvin L. Jones has been assigned as application engineer to the Newark, N. J. office of Reliance Electric and Engineering Co., and **Thomas J. Lisy** goes to the Pittsburgh, Pa., office as an application engineer.

Ken W. Grader was named Chicago, Ill., district representative for Heil Process Equipment Corp. Mr. Grader has had sixteen years' experience in the sale and service of chemical-proof process equipment. During the past three years he has been sales engineer in the home office of Heil Process Equipment Corp. at Cleveland, Ohio.

Russell J. Dickson has been appointed general sales manager, Leschen Wire Rope division of H. K. Porter Co., Inc., St. Louis, Mo. Mr. Dickson has been with Leschen for more than three years as Chicago, Ill., district manager.

D. C. Sanford was appointed manager of the application engineering department of Bristol Co., Waterbury, Conn. Mr. Sanford joined the company's sales engineering organization in 1937 and was promoted to Birmingham, Ala., district manager in 1946. In 1948 he became an application engineer with headquarters at the company's main office in Waterbury, Conn.

J. L. Wagoner, after thirty-two years with Westinghouse Electric Corp. has joined Multi-Amp Corp., Harrison, N. J. as vice president and national sales manager. He will be responsible for developing and building the national sales pattern for the various testing instruments manufactured by Multi-Amp.

Thomas E. Akers was elected chairman, **Kenneth T. Fawcett** was named president and **Maynard B. Terry** becomes vice president of the Dominion Brake Shoe Co., a subsidiary of American Brake Shoe Co.

H. S. Pahren has been elected a commercial vice president for Elliott Co., Jeannette, Pa. **W. E. Widau** and **J. H. Strickler** were also elected commercial vice presidents.

William D. Jameson, formerly with Yale and Towne Manufacturing Co., has been appointed general sales manager for the Electric Service Manufacturing Co., Philadelphia, Pa. Under the general reorganization of the company sales program, **I. W. Schmidt,** vice president and former sales director, will direct a new department of market research. At the same time, the company announced the appointment of **Harold A. Geatrell** as advertising and sales promotional manager.

Paul Ascenzo was named as a sales engineer in their New York, N. Y., territory for Laclede Arch Co. Mr. Ascenzo was formerly with American Arch Co., where he designed and erected open hearth furnaces for several large steel companies.

A. L. Thurman was named executive vice president of Mannesmann-Meer Engineering and Construction Co., Easton, Pa. Mr. Thurman comes to Mannesmann-Meer after seven years of mill machinery experience with Aetna-Standard Engineering Co. Prior to that

A. L. THURMAN

time he was with the General Electric Co. for over eight years, the last five years of that period having been spent as a steel mill application engineer in the steel mill division.

Richard E. Hoierman has been named advertising manager for the machinery division of Dravo Corp. and the Dravo-Doyle Co., a subsidiary. Mr. Hoierman succeeds in the post **Robert C. Black,** who has been transferred to the sales staff of the division's heating department.

(*Please turn to page 283*)

POLLOCK'S *Economic Impact in the Steel Industry*

Ever since Pollock designed and built the first steel plate blast furnace shells to replace the early stone shells, Pollock ingenuity and equipment have increased efficiency and reduced costs in steel plants throughout the world.

The modern installations pictured here were furnished by Pollock for the new Youngstown Sheet & Tube Company blast furnace and open hearth at Indiana Harbor.

They are typical of the giant accomplishments steelmakers everywhere expect of The William B. Pollock Company . . . specialists in all construction matters pertaining to the manufacture of iron and steel.

250-Ton Welded O.H. Ladle

400-Cu. Ft. Blast Furnace Cinder Cars

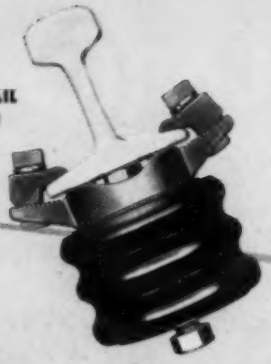
100-Ton Hot Metal Ladle Transfer Car

Front-flush Slag Car

THE WILLIAM B. POLLOCK COMPANY
YOUNGSTOWN OHIO
STEEL PLATE CONSTRUCTION
ENGINEERS · FABRICATORS · ERECTORS
Established 1863

KEYSTONE INSULATORS for INDUSTRY

CONTACT RAIL (TYPE BMS)



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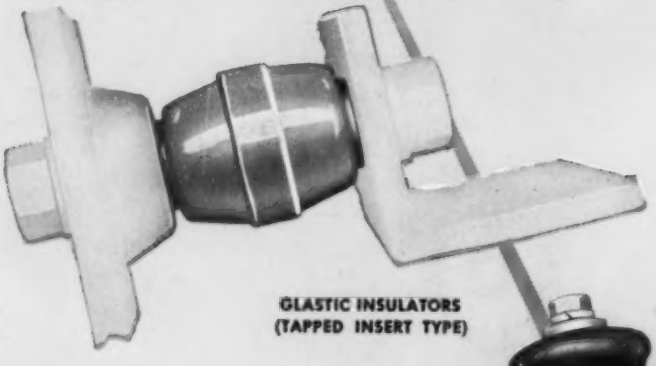
FOR UNFAILING PROTECTION ON THE TOUGHEST JOBS!

For longer, stronger life and peak protection, there's a Keystone Industrial Insulator that's "service-engineered" to meet every need. Let ESM engineers help you select the right mechanical and electrical qualities to solve your insulator problems. Call on them soon.

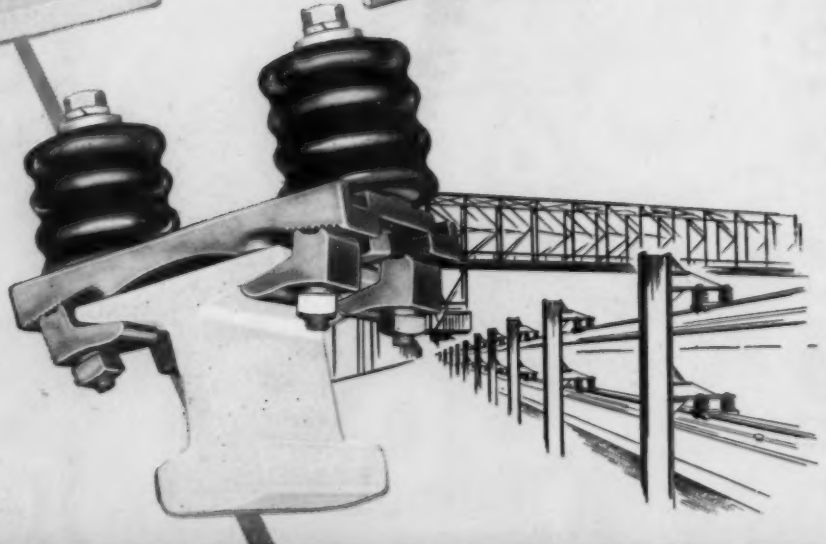
MOULDED GLASTIC INSULATORS

Fibreglass reinforcement and superior compounds provide maximum impact strength with excellent resistance to arc track, chemicals, heat and weather.

SUSPENSION INSULATORS



GLASTIC INSULATORS (TAPPED INSERT TYPE)



Basic units shown have great variety of application by use of proper fittings, selected from our Industrial Catalog. Write for illustrated folder.

ELECTRIC SERVICE MANUFACTURING CO.

TAPPED INSERT
(PETTICOAT TYPE)

WET PROCESS
PORCELAIN INSULATORS

Unexcelled electrical characteristics, high mechanical strength. Best for dirty outdoor applications, high voltage, or sensitive control circuits.

TAPPED INSERT
(PETTICOAT TYPE)

DRY PROCESS
PORCELAIN INSULATORS

CONTACT
RAIL
(TYPE DD)

Rugged, economical assemblies for low voltage power circuits.

CONTACT
RAIL
(TYPE HA)

MOULDED PHENOLIC
INSULATORS

Compact, protected suspension units combine good mechanical strength with dependable low voltage performance. Strain insulators offer maximum tensile strength.

GIANT STRAIN
INSULATOR

"SERVICE-ENGINEERED"
BY
ELECTRIC SERVICE

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MORE STANDARD SIZES TO CHOOSE FROM

In the range from 1 to 400 horsepower JONES offers the most complete line of Herringbone Gear Speed Reducers available *ANYWHERE*.

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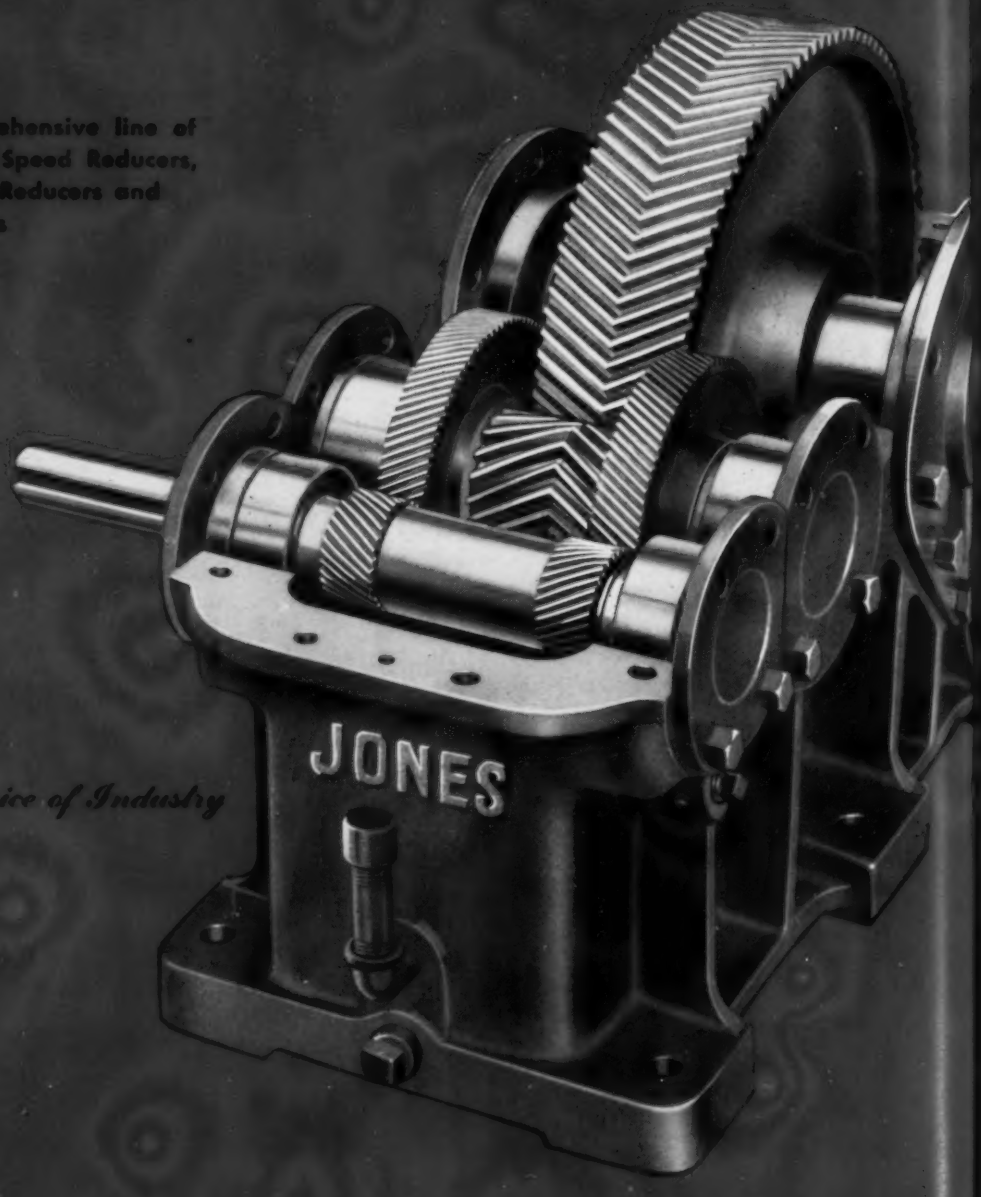
Manufacturers of a comprehensive line of quality Herringbone Gear Speed Reducers, Worm Helical Gear Speed Reducers and Worm Gear Speed Reducers



Since 1890 . . . In the Service of Industry

W. A. JONES FOUNDRY & MACHINE COMPANY, 4457 Roosevelt Road, Chicago 24, Illinois

(*Continued from page 278*)

E. A. Humble was named district manager of the Boston, Mass., office of Elliott Co. **M. C. Seeman** was named manager of the Cleveland, Ohio, office, and **O. M. Sievert** becomes manager of the Kansas City, Mo., office.

C. A. Brashares and **Richard S. Moore** have been named assistant general sales managers of Harbison-

C. A. BRASHARES

Walker Refractories Co., Pittsburgh, Pa. **George M. Ullom** has been appointed sales manager of the company's Birmingham, Ala., district, and **Joseph D.**

RICHARD S. MOORE

Custer has been named sales manager of the Portsmouth, Ohio district.

Chester D. Rugen, projects engineer, has been appointed assistant chief engineer, and **Robert B. Jordan,** assistant chief construction engineer, construction engineering Bureau, U. S. Steel Corp., Fairless works, Morrisville, Pa., is also appointed assistant chief engineer for the Universal Atlas Cement Co., a U. S. Steel subsidiary.

Fred Kaiser was named manager of the eastern region of Minneapolis-Honeywell Regulator Co., with headquarters in New York, N. Y. **Arnold Michelson,**

. . . and production is up

with AIRE-RECTIFIERS

Here is a hot job in a large steel mill. Every time the crane taps a pit, it picks up a mass of molten metal at 2400 F. for delivery to the receiving table. Blasts of hot air soar upward.

Yet — the crane operator works efficiently in a comfortable temperature due to a Lintern Aire-Rectifier. The cab unit is located conveniently in the cab and the condenser unit on the footwalk.

Five cranes and two pulpits are air conditioned in this plant — and more are planned. These Aire-Rectifiers mean greater production, improved employee relations and less turnover of skilled labor.

Hot weather is on the way — write or wire us today about your needs.

THE LINTERN CORPORATION

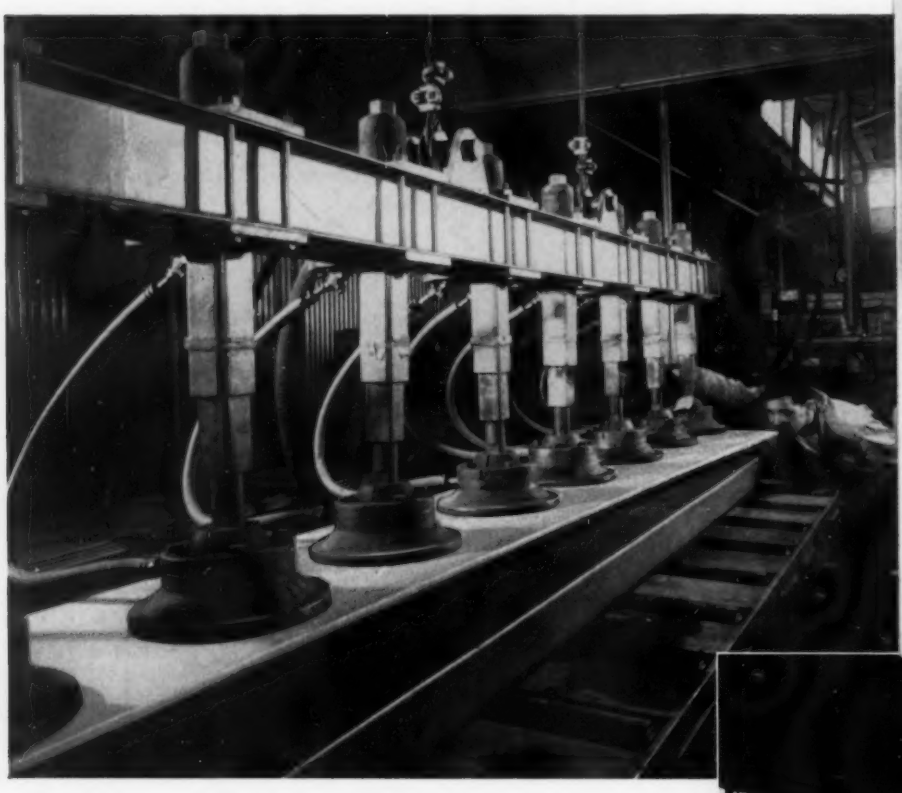
Route 20, East Painesville, Ohio

Another package job by P.E.C.

The new CLADMETAL project of SUPERIOR STEEL CORPORATION

CARNEGIE, PA.

Capacity 80,000 tons of Clad Steel Stock per year



MAJOR SERVICES

Incoming Power Sub-station
Power Distribution
Acid Storage
Steam System
Compressed Air

MAJOR PROCESSES

Straighten Billets
Assemble 3 Layer Sandwich
Submerged Arc Weld
Hot Roll & Coil
Anneal
Pickle
Cold Roll
Coil

The recently completed plant of the Superior Steel Corporation at Carnegie, Pa., for the bonding or cladding of metals, represents high achievement in a comparatively new yet vital industry.

We congratulate the management for its initiative, its vision and its courage which made this important development possible.

The plant equipment was field engineered and installed under P-E-C single responsibility.

PATTERSON·EMERSON·COMSTOCK, INC.

Engineers and Constructors

313 East Carson Street • Pittsburgh 19, Pa.

who has been handling the regional manager's duties, has been given additional duties and responsibilities as resident vice president. He will continue to make his headquarters in New York.

Charles H. Smith, who joined the L. J. Wing Mfg. Co., Linden, N. J. in 1920, has been named vice president, in addition to his duties as secretary and director in which capacities he has been serving since 1943.

F. B. O'Mara was appointed manager, metallurgical carbon sales for National Carbon Co., a division of Union Carbide and Carbon Corp., New York, N. Y. Mr. O'Mara joined the National Carbon Co. in 1946. For several years he was interested in the manufacture of carbon and graphite, at the several plants of the company, where a large percentage of the carbon and graphite products used in the ferrous and non-ferrous industries are made.

J. E. Allison, formerly assistant to director of personnel relations of Jones & Laughlin Steel Corp., Pittsburgh, Pa. was named assistant director—labor relations. **Karl R. Brunt,** former supervisor of education and training, was made coordinator—training and recruitment. **Peter S. Wainwright,** formerly labor relations analyst, was appointed supervisor—training. **Norman G. Burgess,** formerly personnel assistant, was named supervisor—employment.

Robert M. Parke has been named manager of the materials and processes section of the metallurgy research department in the General Electric research laboratory.

A. B. Capron, formerly chief engineer, has been named assistant works manager in charge of the tube mills and engineering, and **Newell Hamilton,** formerly superintendent of the steel mill, has been appointed

A. B. CAPRON

manager of steel operations in the Tubular Products division of Babcock & Wilcox Co., Beaver Falls, Pa., according to an announcement made here recently by Paul J. Utnehmer, works manager. Mr. Capron joined B&W in 1937 as a mechanical engineer. He was successively promoted to assistant superintendent of the hot mills and superintendent of the tube mills. He was named chief engineer in January 1952, and directed many plant improvements and additions made during the past eighteen months. Mr. Hamilton came to B&W as metallurgist in 1928. He became research metallurgist

NEWELL HAMILTON

in 1932 and was responsible for the development of several new alloys introduced by the division and their application to industrial uses. In 1936 he was made metallurgical engineer and was assigned to work on plans for an electric furnace steel plant. In June 1942, Mr. Hamilton was appointed superintendent.

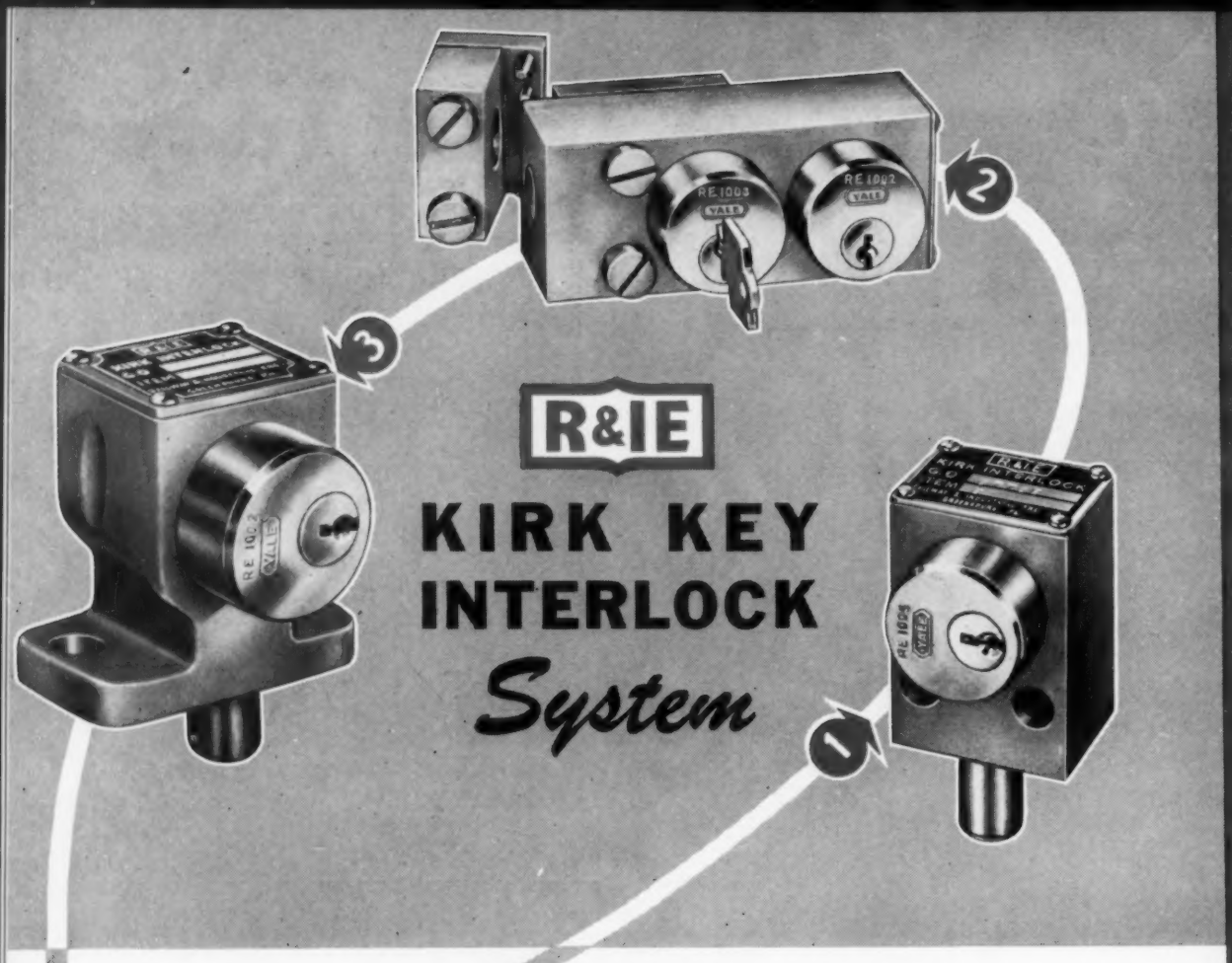
Dr. Clyde McKinley has been appointed director of research for Air Products, Inc., of Allentown, Pa. During the past ten years Dr. McKinley has been associated with the research staff of the General Aniline and Film Corp.

Edward D. Fagan has been appointed sales engineer for materials handling equipment by Heppenstall Co., Pittsburgh, Pa. Mr. Fagan has been serving as plant engineer at Eddystone, Pa.

W. D. Sullivan, assistant works manager of the Tubular Products division of Babcock & Wilcox Co. at Beaver Falls, Pa., has been transferred to the company's boiler division. Mr. Sullivan will be regional manager of the boiler division, manufacturing department.

F. W. Borchers has been appointed general sales manager of Bristol Co., Waterbury, Conn. Mr. Borchers joined the Bristol sales engineering organization in 1922 and in 1933 was appointed district manager of the company's Birmingham, Ala., office. In 1935 he became district manager of the Philadelphia, Pa., office and in 1946 district manager of the New York, N. Y., office. In 1948 he was appointed assistant sales manager.

Walter F. Senkus has been appointed regional sales representative of the De Laval Steam Turbine Co., Trenton, N. J. In his new capacity, Mr. Senkus will specialize in turbine and power plant equipment sales in the company's midwest region which includes the Chicago, Ill., Minneapolis, Minn., and Detroit, Mich., areas. Formerly located in the Detroit office, Mr. Senkus now has his headquarters in Chicago.



R&IE KIRK KEY INTERLOCK *System*

KEY . . . YOUR OPERATIONS FOR SAFETY

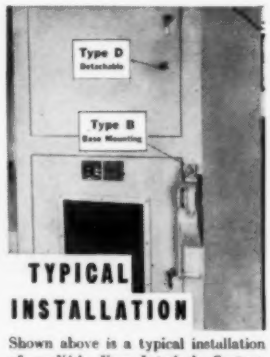
Kirk Key Interlock Systems prevent the authorized person from doing the unauthorized thing! Added safety for your installation and equipment is provided by this device which is applied to two or more movable parts, preventing or allowing movement of one part only when another part is locked in a predetermined position. Unlimited operating schemes can be arranged in electrical installations, processing systems, fluid and pneumatic systems, etc., from combinations as shown, or multiple units of any one of them. Individual locks are mechanical and meet basic mounting requirements. Following are descriptions of the 3 types shown above:

1 **TYPE F**—For flat mounting—Can be mounted on any protective device.

2 **TYPE D**—Detachable....Can be mounted on cell door, gate or compartment. One key retained with door locked open....other key can be retained by operator or used to operate other devices.

3 **TYPE B**—For base mounting—Can be mounted on handle of disconnecting device....Key released when lock is open.

Please write for Bulletin No. 1725 for full description, applications and typical schemes for R&IE Kirk Key Interlocks



TYPICAL INSTALLATION

Shown above is a typical installation of a Kirk Key Interlock System. Fuse compartment can only be opened when interrupter switch is locked open.

R&IE EQUIPMENT DIVISION

I-T-E CIRCUIT BREAKER CO.

GREENSBURG, PA.

The Check List

CONDUCTOR SUPPORTS CLAMPS AND FITTINGS

DISCONNECTING SWITCHES INDOOR AND OUTDOOR

HORN GAP SWITCHES

INTERRUPTER SWITCHES

CUTOUTS AND THERMO-RUPTERS

DISTRIBUTION EQUIPMENT

SWITCH OPERATING MECHANISMS

SUBSTATIONS

OPEN OR ENCLOSED ISOLATED PHASE HEAVY DUTY BUSES

KIRK INTERLOCK SYSTEMS

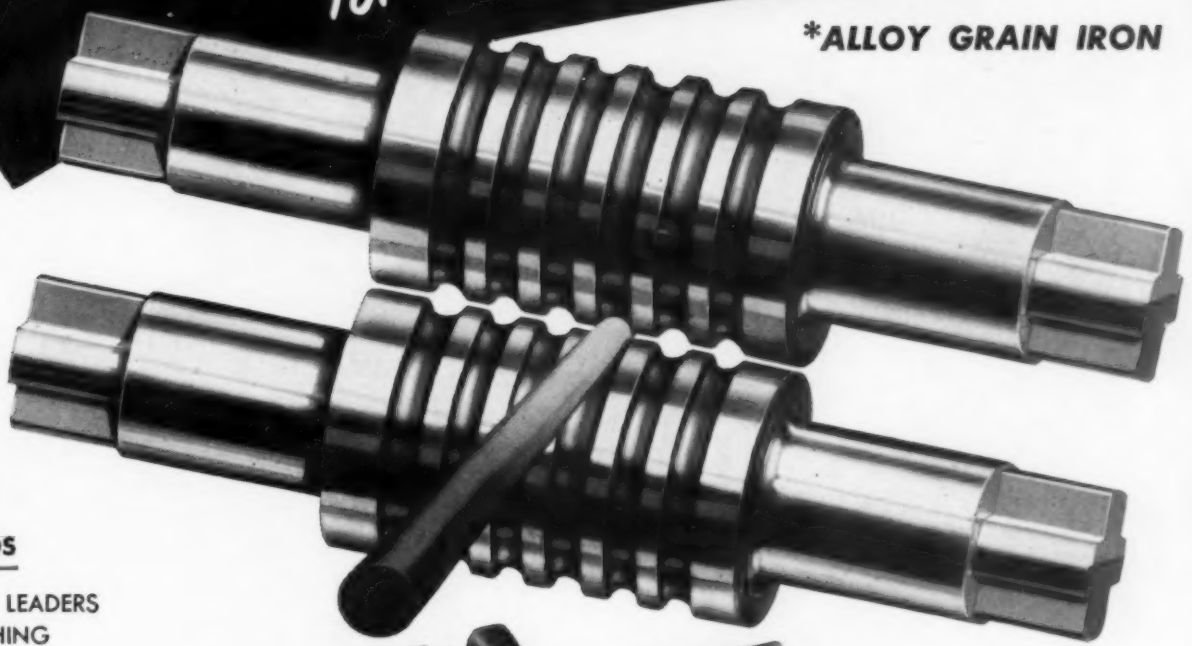
AUTOMATIC SWITCHING EQUIPMENT

METAL CUBICLES

TESTING DEVICES

* PHOENIX "K" ROLLS are color marked for specific uses in rolling . . .

*ALLOY GRAIN IRON



ROUNDS

INTERMEDIATE, LEADERS AND FINISHING

SPLICE BARS

INTERMEDIATE, LEADERS AND FINISHING

P.R.W.

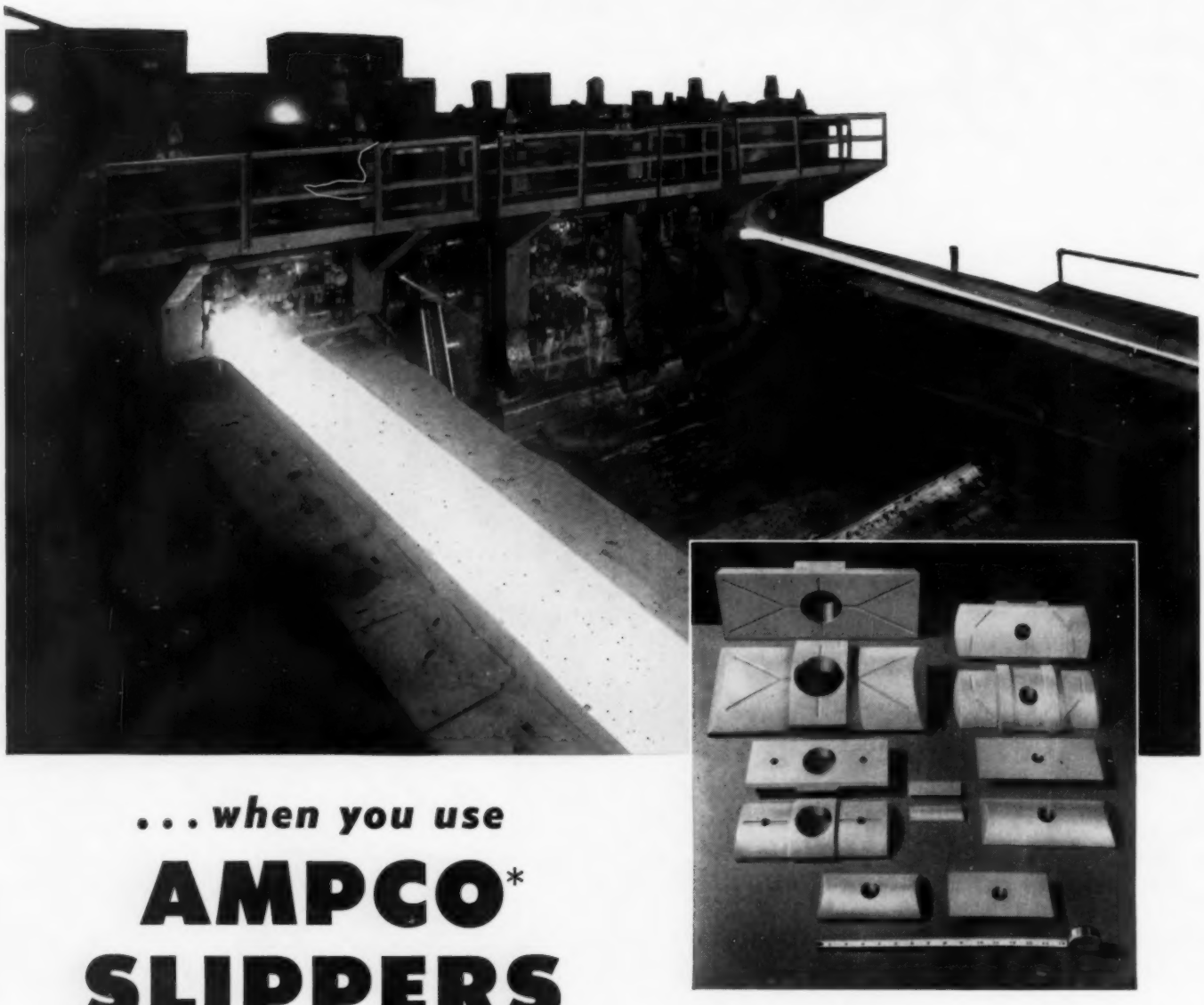
PITTSBURGH ROLLS

BLAW-KNOX COMPANY • PITTSBURGH ROLLS DEPARTMENT • PITTSBURGH, PA.

OTHER PITTSBURGH ROLL TYPES

Chill
Moly Chill
Special Rail Finishing
Pittsburgh Grade 25
Pittsburgh Grade 35
Pittsburgh Grade 45
Pittsburgh Grade 55
Pittsburgh Grade Special Process
Phoenixloy
Phoenix Metal
Phoenix Metal Master
Phoenix "A" Alloy Steel
Phoenix "A" Special Alloy Steel
Carbon Steel

Production Steps Up Costs Step Down



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THERE'S plenty of "plus value" in slippers cast of Ampco Metal. They're tough — have unusual resistance to wear. They withstand the tremendous impacts and shock loads of steel-mill operation without squashing out. They have high fatigue strength.

These properties mean lower costs for you — less downtime — longer runs without replacement.

You get these slippers in the form you need to meet your specific operation. They're available "cast-to-size" or as rough castings. "Cast-to-size Slippers" come either with tolerances of minus 0, plus 1/32; or plus 0, minus 1/32. Oil grooves are cast in, if you want them.

And that's not all. Ampco Metal's stamina, toughness, and corrosion resistance mean that it's ideally suited for cutting costs in other steel-mill applications, too — screw-down nuts, wear plates, flash-welder dies, pickling equipment. Get the whole money-saving story from your nearby Ampco field engineer or write us direct

G-20

*Reg. U. S. Pat. Off.

AMPCO METAL, INC.

AMPCO®

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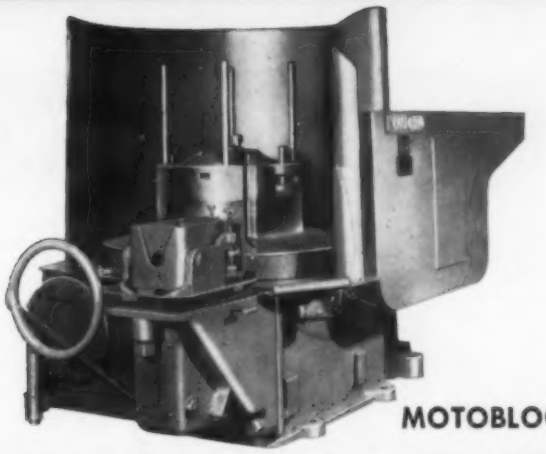
MILWAUKEE 46, WISCONSIN

West of the Rockies it's Ampco's Burbank Plant, Burbank, California

COLD DRAWING EQUIPMENT *exclusively*

® VAUGHN MACHINERY



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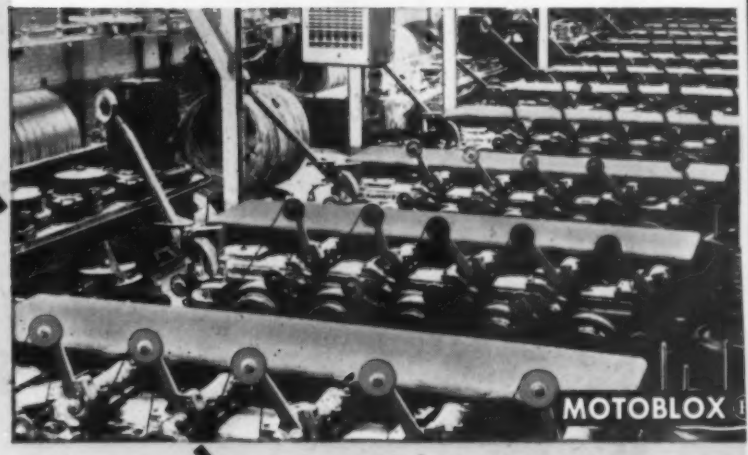

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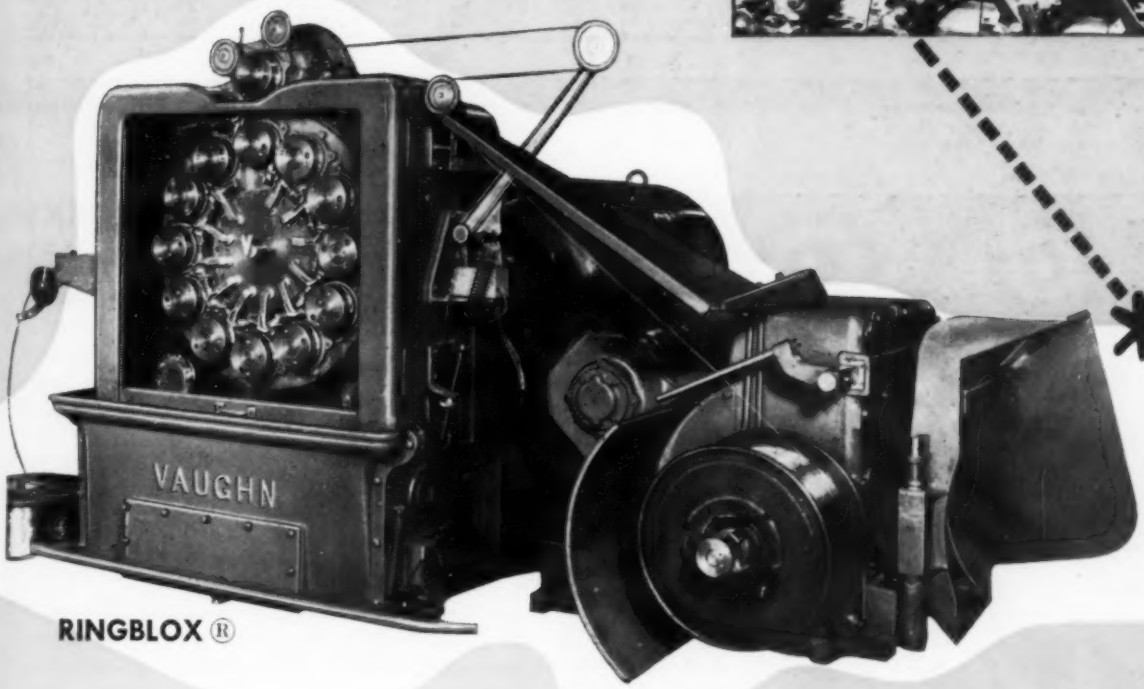

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We're specialists in Cold Drawing Equipment. No other manufacturing interests divide our concentration—one of many good reasons for VAUGHN leadership in the field!

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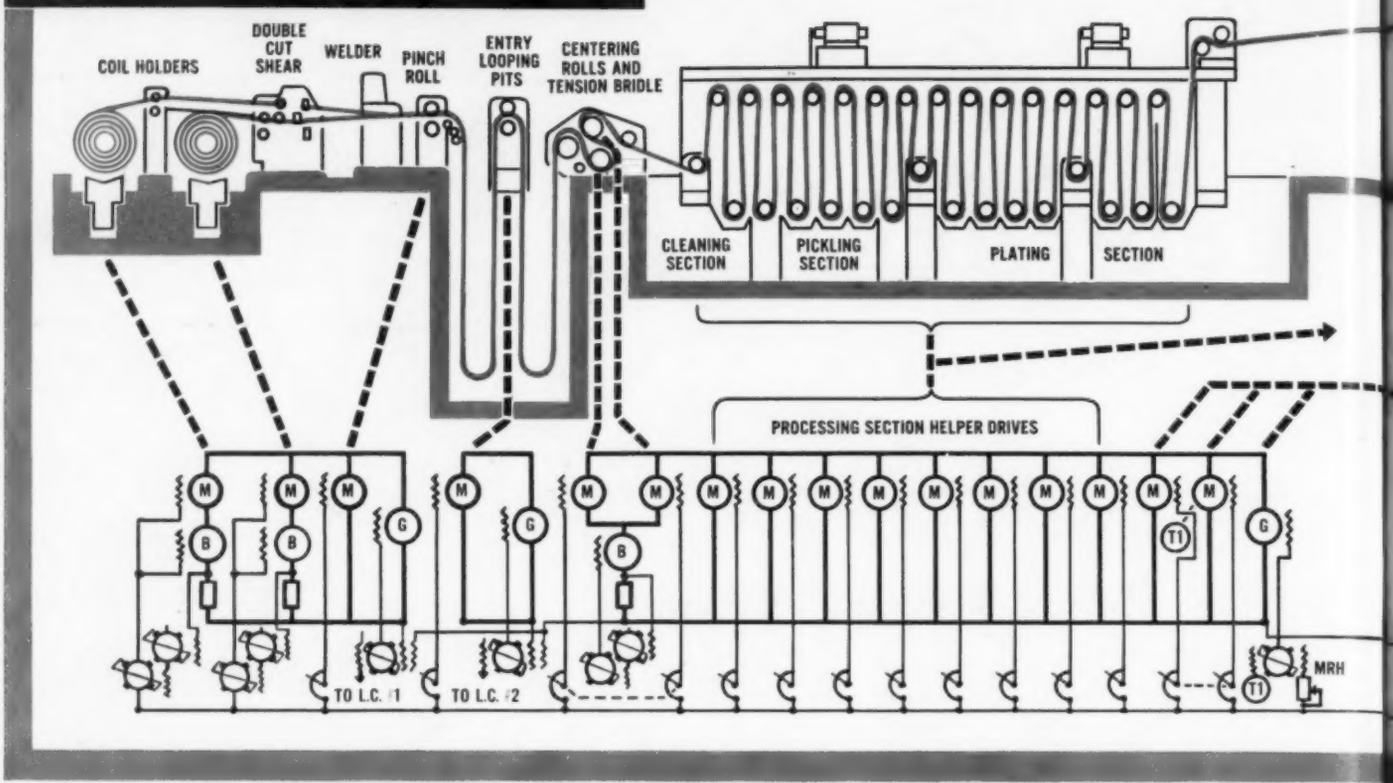
CUYAHOGA FALLS, OHIO, U.S.A.

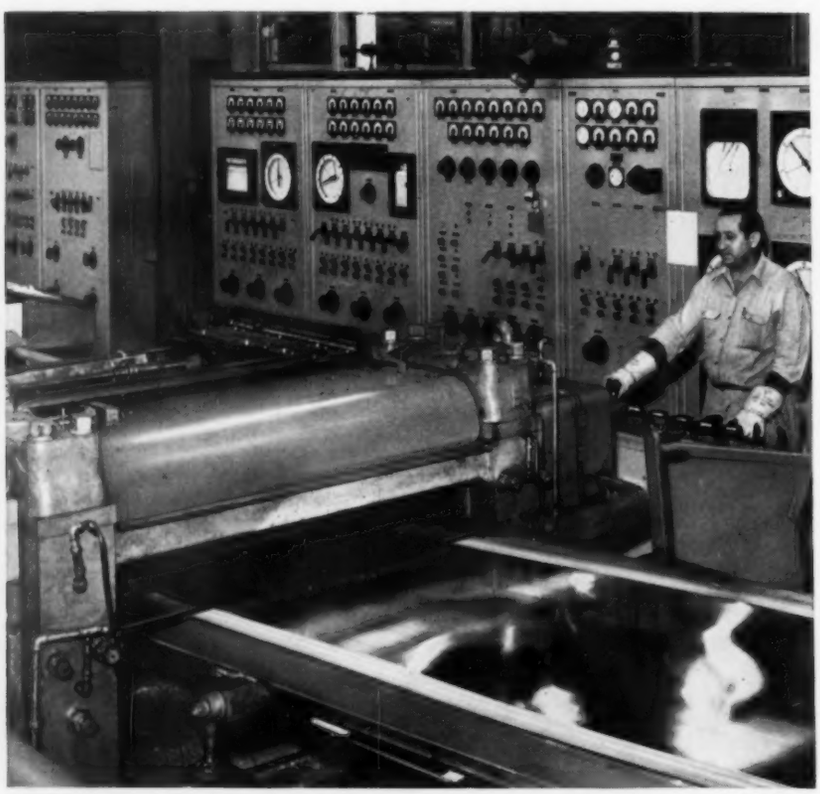
COMPLETE COLD DRAWING EQUIPMENT . . . Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

"Quick on the Draw"

DRAWBENCHES

ENGINEERING REPORTS:





CENTRALIZED CONTROL—Most operations are directed from G-E control desk.

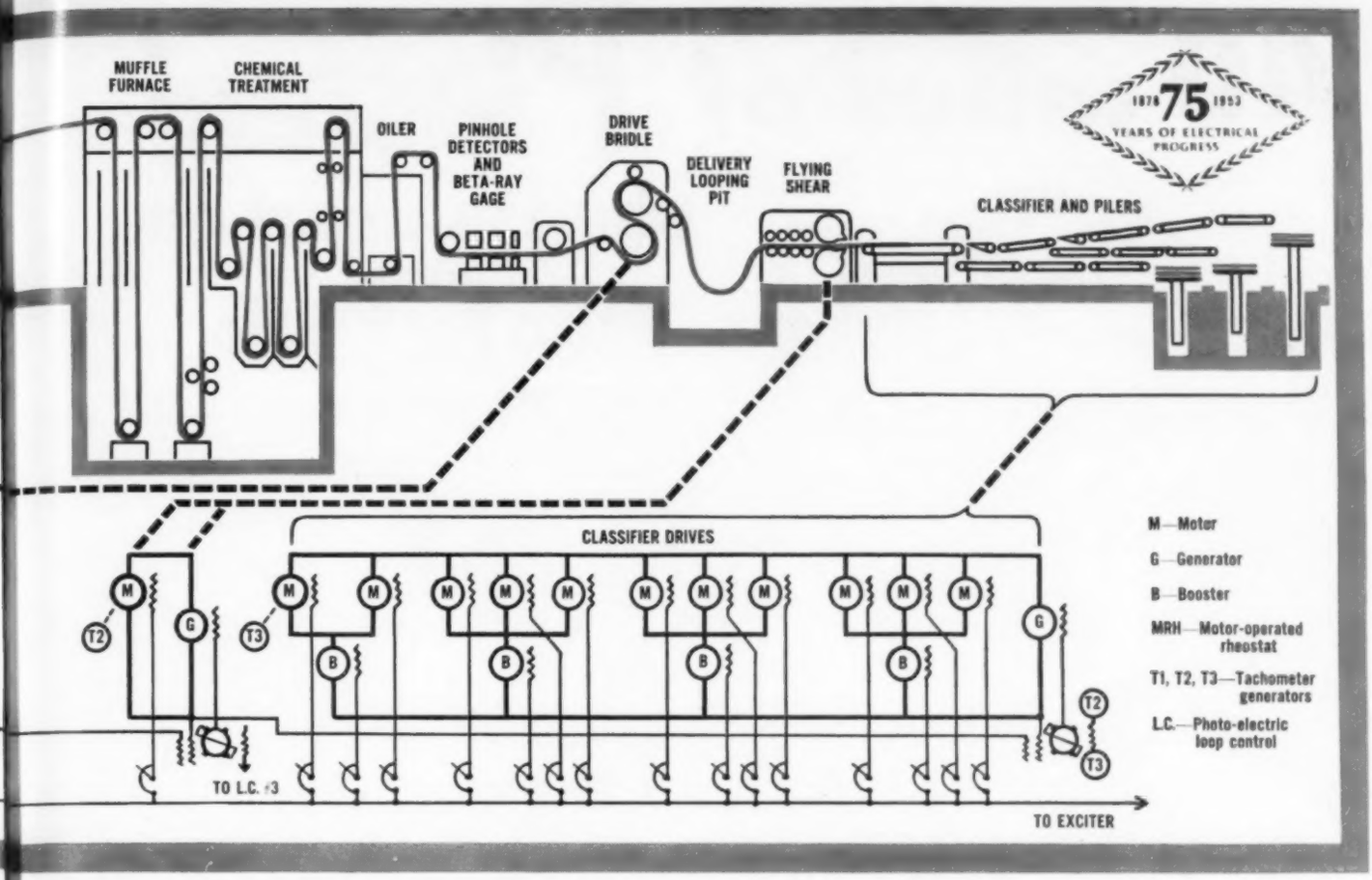
HOW THIS G-E DRIVE WORKS

Speed of the plating section is precisely controlled by an amplidyne which regulates the speed of the drive bridle to the preset speed setting of the main motor-operated rheostat. This rheostat provides a controlled rate of acceleration and deceleration for normal operations. In case of strip breakage, fast stopping is provided by the current-limit circuit, thereby reducing line-rethreading time to a minimum.

Amplidyne voltage regulators on each end-section generator set the speed of the particular section at approximately correct value by comparing section voltage with main plating-section voltage. The photoelectric loop controls act as over-riding verniers to maintain proper loop positions. The classifier generator, however, has a speed-control vernier which compares the speed of the shear with the speed of the classifier belts to maintain the proper speed relation between classifier belts and shear.

Plating-current control involves a high-precision photoelectric galvanometer designed to hold current within one per cent accuracy. The cleaning, pickling and chemical-treatmen low-voltage generators and the two 1500-kv transformers supplying power to the muffle furnace are also accurately controlled.

Another example of G-E drive engineering at work!



World's fastest vertical acid tinning line assures uniform thickness, lower production costs

G-E drive system permits differential coating, improved quality control, shorter weld cycle

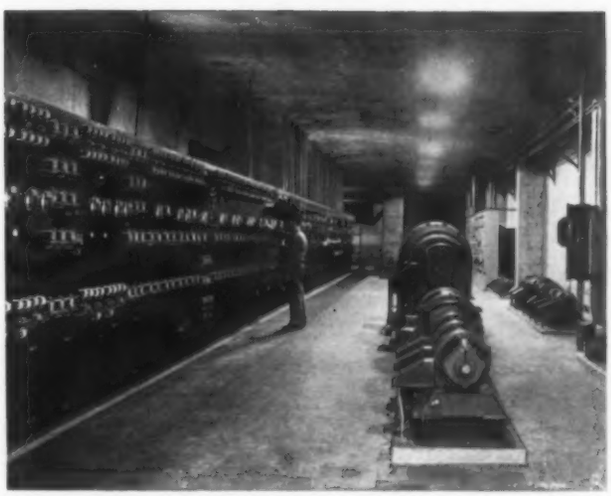
Kaiser Steel Corporation's automatic vertical acid tinning line at Fontana, Cal., built under license from U. S. Steel Corporation, operates at 1200 fpm, fastest speed to date for vertical acid tinning. To help make its high-speed operation continuous, G-E engineers worked with Kaiser Engineers and the Wean Engineering Company to design a precise co-ordinated drive system. Result:

Faster production: Amplidyne voltage regulators speed up drive acceleration and deceleration, cut weld-cycle time.

Tin conservation: Differential coating and precise plating-current control promise savings of 25 to 50 per cent.

Less plate damage: Improved electrical controls on sheet classifier help clear cobbles quickly without stopping line.

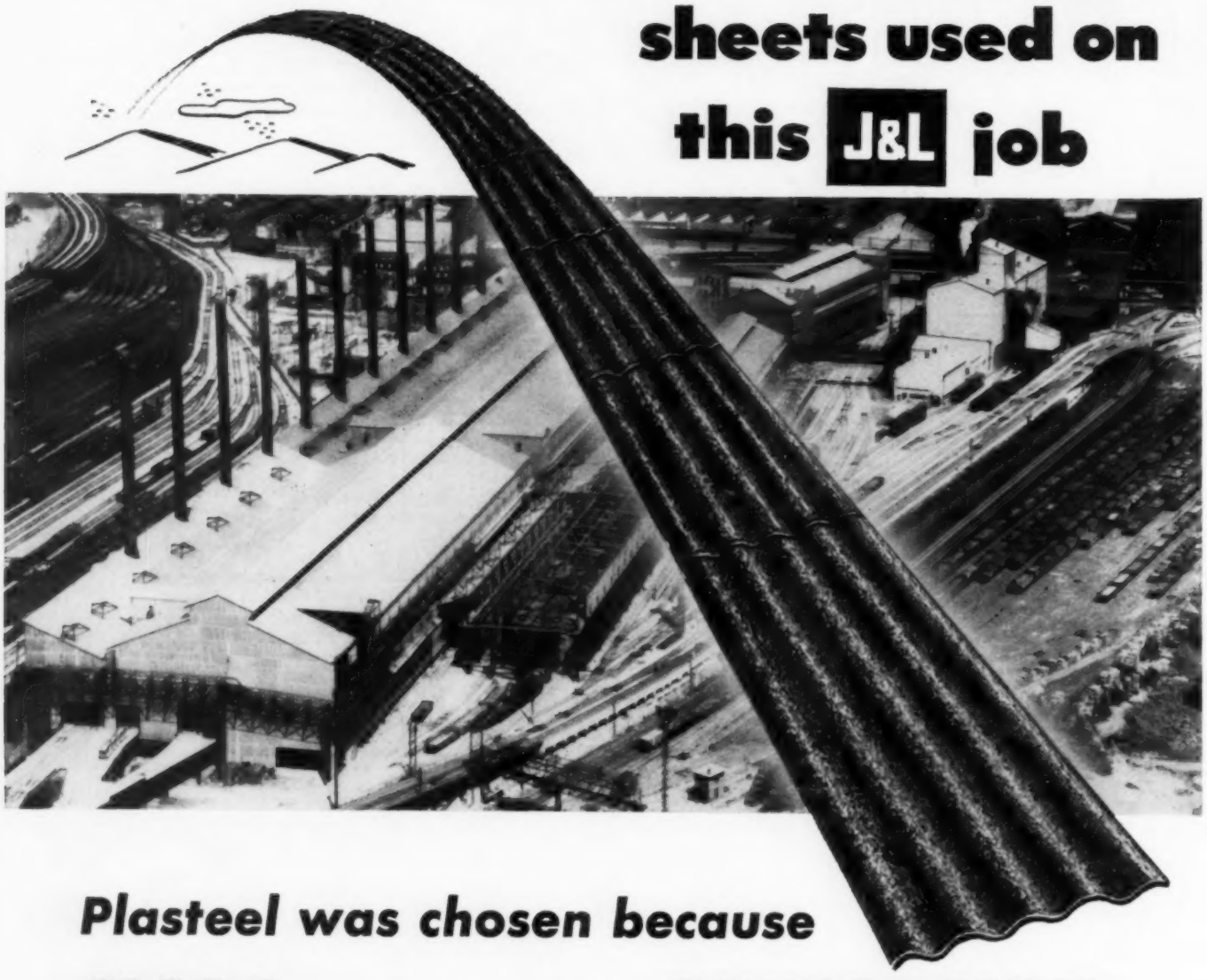
G-E steel-mill application engineers can help you solve your electrical drive and control problems. Contact your local G-E Apparatus Sales Office. General Electric Company, Schenectady 5, New York. 659-94



DEPENDABLE POWER is supplied to the tinning line through G-E motor-generator sets (center). Amplidynes regulate strip speed according to line operator's setting.

GENERAL ELECTRIC

40 miles of Plasteel sheets used on this J&L job



Plasteel was chosen because

MICA makes the DIFFERENCE

40 miles of *Plasteel* sheets—33" wide is a lot of roofing and siding. That, to the plant engineer, is 635,000 square feet of maintenance-free building protection. Only *Plasteel* gives you the advantages of Mica . . . and Mica makes a big difference! The Mica topping reflects the sun's rays and prevents the drying out of the volatile oils in *Plasteel's* asphalt-plastic coating. Mica prevents deterioration and practically eliminates maintenance costs. It provides a tough wearing surface, and gives *Plasteel* a pleasing finish. That's why more industrial building projects specify *Plasteel* today.

If you are planning new buildings, mail PLASTEEL Coupon today.*

PLASTEEL PRODUCTS CORPORATION

WASHINGTON, PENNSYLVANIA

ISE-9-53

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PLASTEEL PRODUCTS CORPORATION
WASHINGTON, PENNSYLVANIA

We are interested in *Plasteel* Roofing and Siding. Please send details checked below:

☐ Engineer's Handbook
☐ Sample of *Plasteel*

Company Name .....

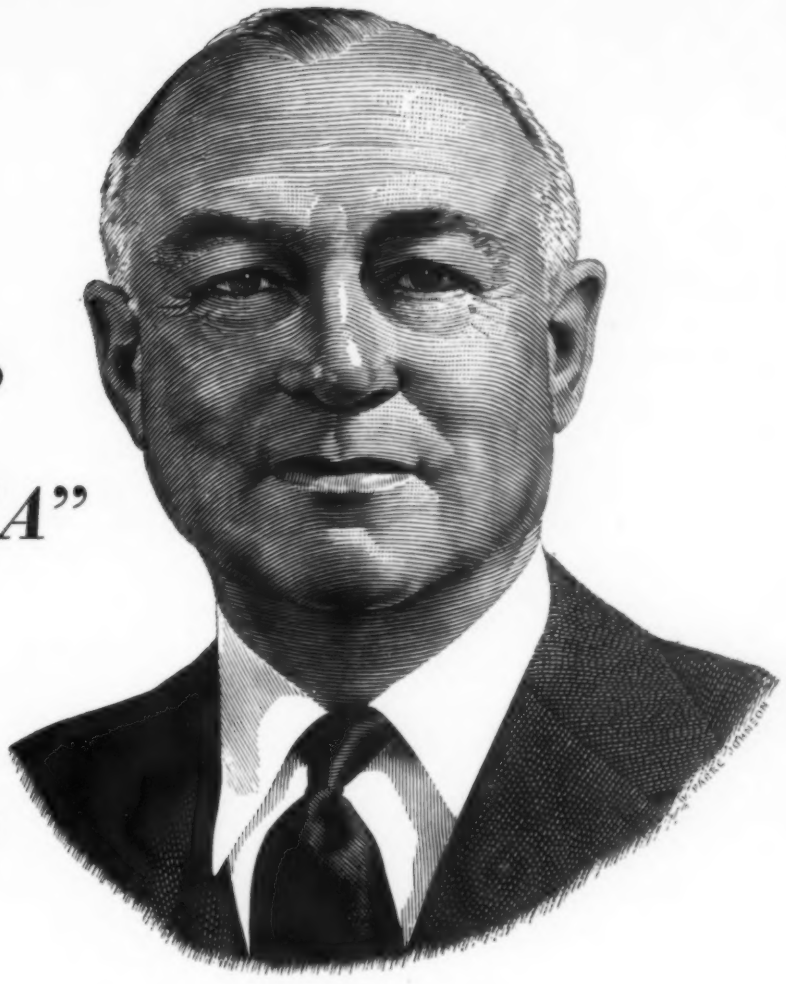
Attention of ..... *Title*

Street or Box No. .....

City ..... *State* .....

MAIL THIS COUPON TODAY!

"...Well done, AMERICA"



GEORGE M. HUMPHREY
Secretary of the Treasury

"Few things in America contribute more importantly to national security than the Payroll Savings Plan—the vehicle through which millions of employed men and women build security, counteract inflation and create a reserve of future purchasing power by their monthly investment in U. S. Savings Bonds. Credit for this outstanding influence in our lives is due largely to a team that is typically American... far-sighted business executives who have made the Payroll Savings Plan available to the employees of 45,000 companies... 8,000,000 Payroll Savers... publishers of more than 500 business magazines and the management of the other advertising media who contribute generously of their space and time... the Advertising Council and advertising agencies who give freely of their skills. To these and to all who have a part in building the Payroll Savings Plan, the U. S. Treasury Department welcomes this opportunity to say, "Well done, America."

Do you know—

• on May 1, 1953, the cash value of Series E Bonds outstanding—the kind bought by Payroll Savers—reached a new record high—$35.5 billion—$1 billion more than the value of E Bonds held on May 1, 1951, when E Bonds commenced to mature.

• cash sales of Savings Bonds, all series, during the first four months of 1953 totaled $1,741,273,000—22% above those of the first four months of 1952.

• of the approximately $6.7 billion E Bonds which had come due up to the end of April, 1953, $5.1 billion, or 75% were retained by their owners beyond maturity.

• every month, nearly 8,000,000 Payroll Savers purchase about $160,000,000 in Series E Bonds.

For assistance in installing a Payroll Savings Plan, or building participation in an existing Plan, write to Savings Bond Division, U. S. Treasury Department, Suite 700, Washington Building, Washington, D. C.

The United States Government does not pay for this advertising. The Treasury Department thanks, for their patriotic donation, the Advertising Council and

IRON AND STEEL ENGINEER

a Wilputte Battery–

76 underjet ovens
with
double collecting mains–
placed in
operation
in a mid-western
steel plant
during 1953

WILPUTTE C

40 R

COKE OVEN DIVISION

ALLIED CHEMICAL & DYE CORPORATION

40 RECTOR STREET • NEW YORK 6, N. Y.

Allied Chemical

BUSINESS EXECUTIVES
CHECK THESE QUESTIONS

If you can answer "yes" to most of them, you—and your company—are doing a needed job for the National Blood Program.

- ○ HAVE YOU GIVEN YOUR EMPLOYEES TIME OFF TO MAKE BLOOD DONATIONS?
- ○ HAS YOUR MANAGEMENT ENDORSED THE LOCAL BLOOD DONOR PROGRAM?
- ○ HAS YOUR COMPANY GIVEN ANY RECOGNITION TO DONORS?
- ○ HAVE YOU INFORMED EMPLOYEES OF YOUR COMPANY'S PLAN OF CO-OPERATION?
- ○ DO YOU HAVE A BLOOD DONOR HONOR ROLL IN YOUR COMPANY?
- ○ WAS THIS INFORMATION GIVEN THROUGH PLANT BULLETIN OR HOUSE MAGAZINE?
- ○ HAVE YOU ARRANGED TO HAVE A BLOODMOBILE MAKE REGULAR VISITS?
- ○ HAVE YOU CONDUCTED A DONOR PLEDGE CAMPAIGN IN YOUR COMPANY?
- ○ HAVE YOU SET UP A LIST OF VOLUNTEERS SO THAT EFFICIENT PLANS CAN BE MADE FOR SCHEDULING DONORS?

Remember, as long as a **single** pint of blood may mean the difference between life and death for **any** American . . the need for blood is **urgent**!

NATIONAL BLOOD PROGRAM

this man has ice water in his veins!

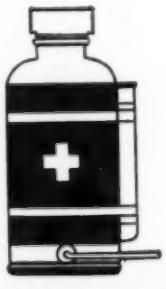
Of course he'd never volunteer to give blood, anyway. But any resemblance of this old duffer to the average, red-blooded American is a mistake.

For instance, several million healthy Americans have given blood. *But it's not enough.*

So this is to tell several million more Americans that their blood is needed—now!

We've never let anyone down who was in trouble. When a GI gets wounded and suffers *shock*—he's in bad trouble. He's got to have blood and lots of it! Folks here at home need blood too—to save their lives.

So make a date with your Red Cross, Armed Forces or Community Blood Donor Center. *One* hour and you're on your way.



GIVE BLOOD

...give it again and again

LEWIS ROLLS

are your tools

FOR MORE TONNAGE THROUGH THE ROLL TRAIN

OVER 90 YEARS LEWIS OF ROLL MAKING

MOLYBDENUM CHILLED IRON ROLLS
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TONNAGE

SUPERIOR "X" ROLLS
AJAX DUPLEX ROLLS
SPECIAL PROCESS ROLLS
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ATLAS, ATLAS "B" AND
ATLAS "X" ROLLS

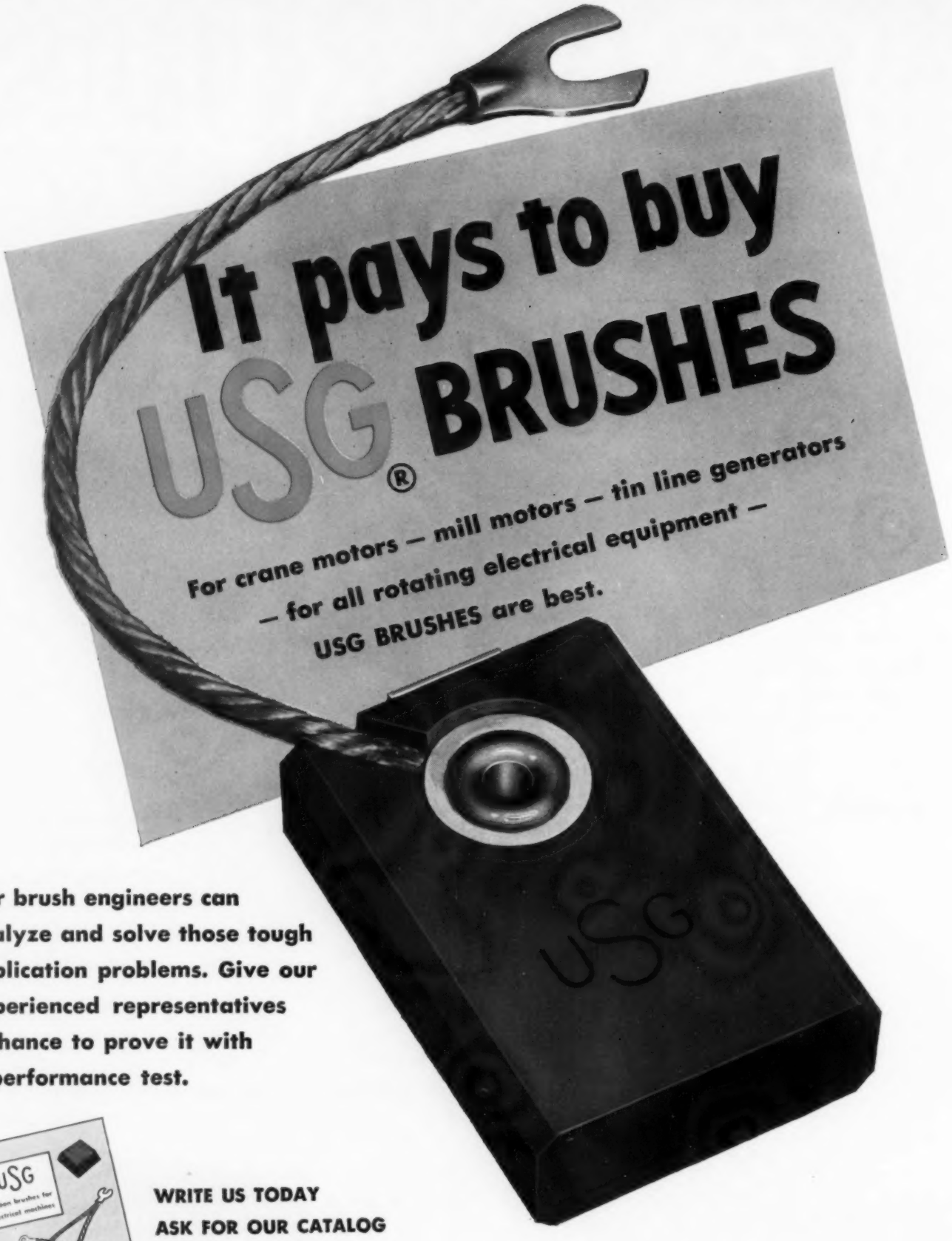
may we have the opportunity of studying your requirements and submitting our recommendations

MANUFACTURERS OF
ROLLS FOR THE IRON, STEEL AND
NON-FERROUS INDUSTRIES

ROLLS DIVISION OF BLAW-KNOX COMPANY, PITTSBURGH, PA.

It pays to buy USG® BRUSHES

For crane motors — mill motors — tin line generators
— for all rotating electrical equipment —
USG BRUSHES are best.



Our brush engineers can analyze and solve those tough application problems. Give our experienced representatives a chance to prove it with a performance test.

WRITE US TODAY
ASK FOR OUR CATALOG

178

THE UNITED STATES GRAPHITE COMPANY

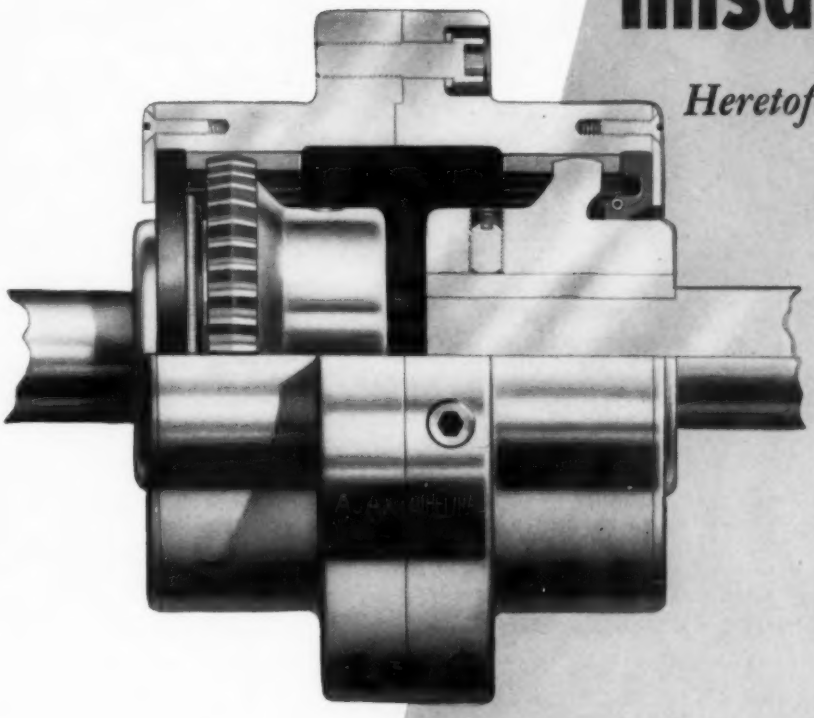
DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

AJAX DIHEDRAL

FLEXIBLE COUPLINGS

provide for AND protect against misalignment

Heretofore Considered Excessive



Ajax Dihedral surfaces of gears provide maximum bearing area and do not tend to rupture the oil film. This contributes to long life, cool running and quiet, chatter-free operation.

All gear teeth hardened to 50 to 55 Rockwell C.

* The performance of Ajax Dihedral Couplings confirms the fact that *there is no competition with quality.*

Design, installation and maintenance men are saving thousands of hours, and dollars by eliminating necessity for precision alignment of direct-connected machines.

New and exclusive Ajax Dihedral tooth shape provides for extreme misalignment with tooth clearance (backlash) kept to oil film requirements. Long life is assured because more tooth contact is maintained under operating conditions.

Positive oil seals keep lubrication in and dirt out.

Write for Bulletin 50.

AJAX FLEXIBLE COUPLING CO. INC.

WESTFIELD, NEW YORK

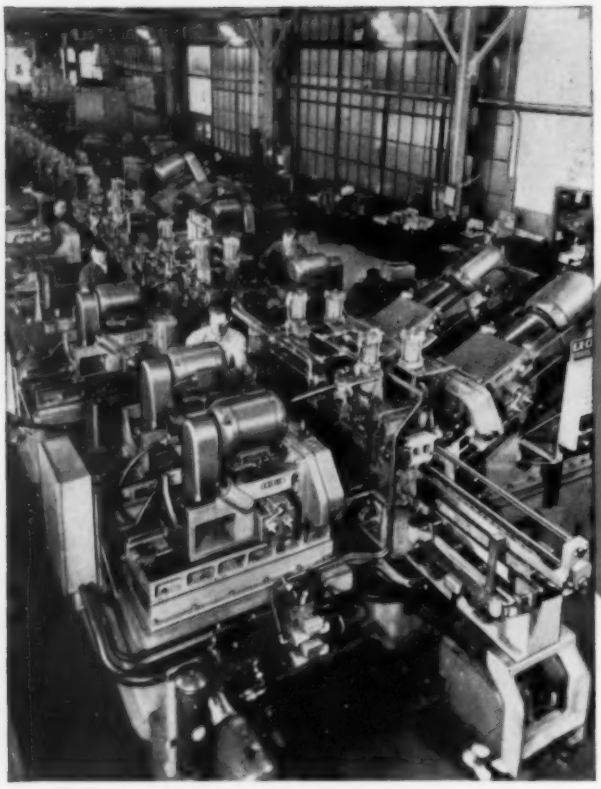


Photo Courtesy Ex-Cell-O Corp., Detroit, Mich.

Trabon

AUTOMATIC LUBRICATION
used on transfer machines
in large automotive plant

this has a BEARING on the subject

Illustrated here are transfer machines typical of several installed in the manufacturing plant of a large automotive producer . . . the first of which was put in operation during the early part of 1951.

Each of these machines is being automatically lubricated with a TRABON system. Two systems cover 195 bearing points each; two, 151 points each; and two, 305 points each.

Each system is so proportioned that slides, ways and heavily loaded working bearings receive the proper amount of lubricant every 20 to 30 minutes. All minor bearings on fixtures receive the exact amount of lubricant required every four hours.

Whether your problem is to lubricate a hot metal crane, crushers, ore unloaders, presses, rolling mills, blast furnaces, boring mills, or any other industrial application . . . a TRABON system is your answer.

Completely sealed—positive—hydraulic—handles oil or grease—backed by years of experience.

WRITE FOR BULLETIN 529

Trabon

ENGINEERING CORPORATION
1814 E. 40th STREET • CLEVELAND 3, OHIO
Oil and Grease Systems

Equipment News...

SCALE MODEL LAYOUT

▲ The use of a scale model of the new air force heavy press plant at Cleveland, Ohio, has allowed Aluminum Co. of America to use the tremendous knowledge of the men at the shop level in planning the plant layout.

Construction and production engineers first developed their ideas for the new plant layout on drawings and blue prints. These show the project in two dimensions, and require study to interpret — even for those whose ideas are involved. The use of a scale model provides a simple method for checking clearances and space required in three dimensions. The model offers a further great advantage by enabling shop supervisors, foremen, and workmen to make constructive suggestions for improvement of the layout. The model's cost of $6500 was more than justified by the opportunity it provided to draw on the production knowledge of these men.

A model plant layout had another unusual value in this case since the size of the equipment and operations is without precedent. The plant, which will be operated by Alcoa under a lease arrangement, is to house two of the largest metalworking presses in the world. The presses of 35,000 and 50,000 tons capacity will forge large aircraft parts from aluminum and magnesium. In addition, the auxiliary equipment for the presses will be of unprecedented size.

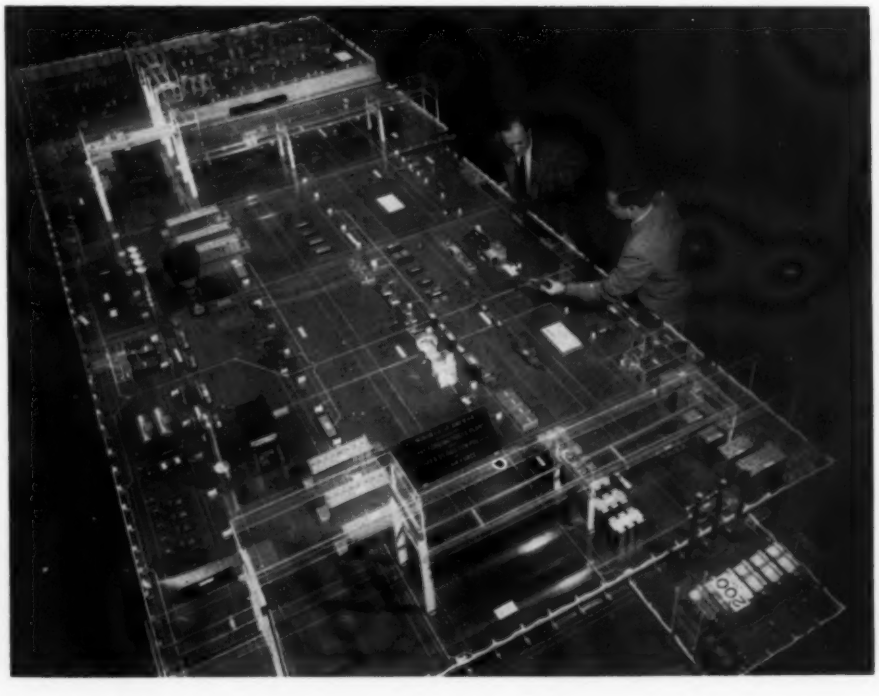
In the section of the shop where the press die blocks will be machined, for example, the model enabled the most efficient placement of equipment for handling and working with the big steel blocks. This will avoid expensive readjustment of massive equipment after the plant is completed.

The model layout was built to a scale of ¼ in. equals 1 ft. The grid lines on the plastic floor of the model are spaced ¼ in. apart to represent 1 ft spacing in the finished plant. The lines which are laid out on the floor of the model represent subterranean structures such as sewers, water and air lines. Foundations will be shown when plans for them are complete.

At several locations on the model cross sections of the plant building are built-up. These are included to show typical vertical clearances in the building and to give the untrained person a sense of proportion.

Alcoa has used models for plant layout work since 1942.

This scale model layout of Alcoa's new heavy press plant at Cleveland, Ohio, permits the men from the shop level to assist in its planning. In addition it provides a simple method for checking clearances and space requirements.



GIANT COUPLING

▲ To transmit as much as 62,000 hp in straight-line at a huge steel plant plate mill, a self-aligning coupling has just been built.

The all-metal coupling was made in the Fast's coupling department of Koppers Co., Inc. Custom-built, it required six months to machine and assemble. It now is ready for shipment to Milan, Italy where it will carry power to a Mesta 110-in., four-high reversing plate mill.

Industrial couplings are used between electric motors and the equipment they drive to transmit power and, at the same time, compensate for the inability to get and maintain 100 per cent perfect alignment of the drive shafts of the two.

Until this coupling was built, largest couplings heretofore could transmit as much as 50,000 hp. Some idea of the size of the one just completed is shown by the fact that the motor hub had to be machined to fit a shaft 32.5 in. in diameter.

STRAIGHTENER

▲ A new straightening machine designed particularly for heavy-duty straightening of hot-rolled bars and heavy-walled tubes has been announced by Sutton Engineering Co.

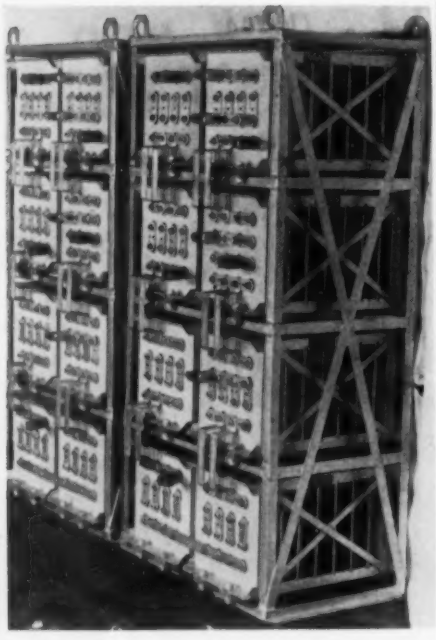
The new straightener is equally adaptable for steel and non-ferrous tubes and round bars such as heavy-walled seamless tubing or alloy heat-treated hot-rolled bars.

Tubes from 1 in. outside diameter to 10 in. outside diameter and bars from 1 in. diameter to 6½ in. diameter can be straightened at speeds up to 320 fpm with good results. Any 4 to 1 ratio, such as 50 to 200, 70 to 280 or 80 to 320 fpm can be furnished depending upon the requirements of the particular application.

A typical application is a unit

GUYAN RESISTORS

CAN END YOUR RESISTOR TROUBLES!



Featuring helical coil resistance elements of chromium alloy steel, GUYAN Resistors are ruggedly constructed to withstand shock, vibration and overload.

•

GUYAN RESISTORS ARE CUSTOM BUILT TO YOUR REQUIREMENTS

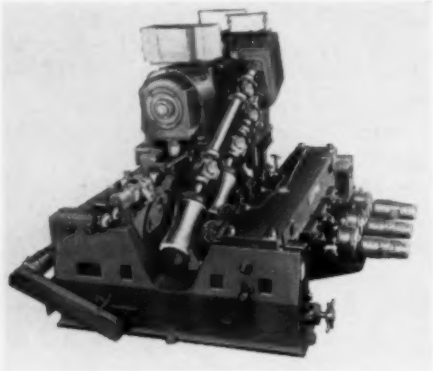
•

GUYAN MACHINERY CO.

LOGAN, W. VA.

equipped with a 125/150 hp, 300/1200 rpm adjustable speed 230 volt d-c motor with a straightening speed of 60 to 240 fpm for tubes up to 10 in. outside diameter.

Known as the 3BC, the machine employs the Sutton 5-roll principle of straightening in which a central pressure roll is located between two sets of opposed rolls, each set having one driven roll and one idler roll. As the straightening load is distributed over three points, it does maximum work per pass, which results in quality end-to-end straightening.



All controls are accessible; all major adjustments are motorized and are operated from a control pulpit. The angular adjustment of the two driven rolls is shown on two large dials, clearly visible to the operator who is able also to observe the straightening operation in the pass line at all times.

A heavy-duty gear drive incorporates Sutton Universal Joints for long, trouble-free life and an enclosed one-shot central lubrication system protects all points which require frequent lubrication. Anti-friction bearings are used throughout.

Compact in design for such heavy-duty equipment, the new Sutton straightener occupies a space of only 20 ft long × 15 ft wide × 10 ft high including the drive.

MOUNTING UNIT

▲ A new basic mounting design for "AccuRay" radiation gages has been announced by Industrial Nucleonics Corp.

Featuring a streamlined measuring head and a tapered bracket, the new unit permits a standardization of measuring systems throughout the complete line of AccuRay mountings. According to company officials, the low, compact measuring head simplifies installation on production lines and provides easy access for servicing. The tapered bracket, available in throat depths up to 160 in., is said to be extremely strong and resistant to vibration and shock.

Widely used to measure and control continuous sheet production in the metals, rubber, plastics, paper, and sheet-coating industries, the AccuRay utilizes radiation to give a direct reading of weight or thickness without contacting the sheet.

Of special interest to industries where sheet profile control is important is the new variable-speed scanning mechanism also announced by Industrial Nucleonics. This unit enables the gage to move slowly across sheet — while presenting a continuous profile picture — and then retract quickly to repeat the scanning cycle. When the gage withdraws, the recorder pen remains stationary to mark the beginning and end of each profile reading.

NON-EXPLOSIVE FIXTURE

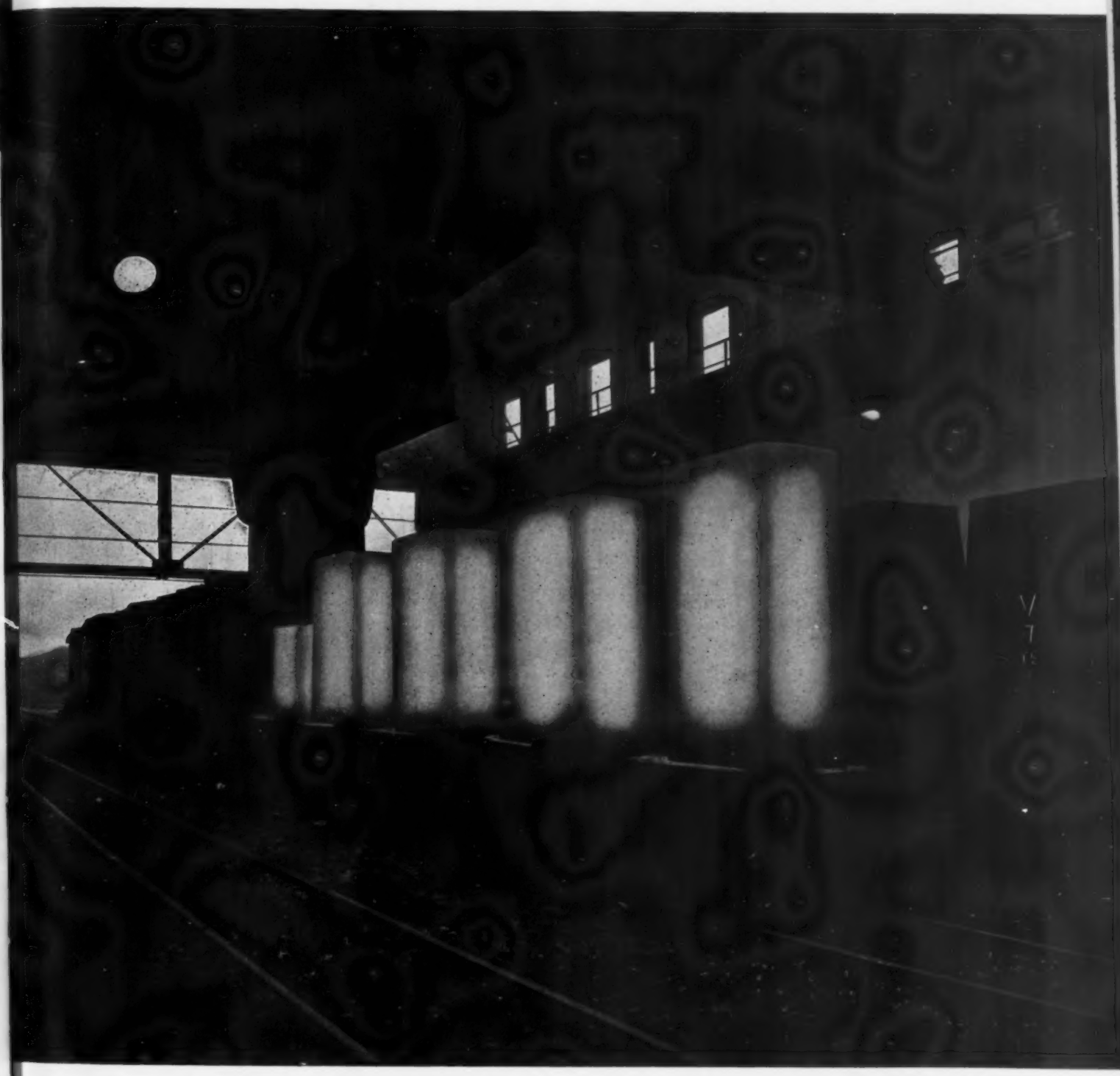
▲ A new type explosion-proof and dust tight fluorescent lighting fixture for use wherever the presence of explosive gases or vapors or combustible dusts requires safe, practical lighting has been introduced recently by Crouse-Hinds Co. The fixture may be spaced end-to-end with other fixtures of its same type, making possible continuous and uniform illumination along work areas.

Each fluorescent tube is housed in

WROUGHT IRON PIPING

Ordinary maintenance of the miles of large-diameter piping used in service lines between the power house and synthetic rubber plant at Goodyear Tire & Rubber Co., Akron, Ohio, involves considerable labor and expense. Where the threat of corrosion creates a special problem giving rise to possible high-maintenance cost, careful attention has been given to selection of material. To protect against damage from corrosion and help keep pipe repairs to a minimum, wrought iron pipe is specified for raw water lines, as well as for the 10-in. steam return piping shown, second from bottom, in the illustration.

MOULDS **VALLEY** STOOLS



VALLEY MOULD & IRON CORP.

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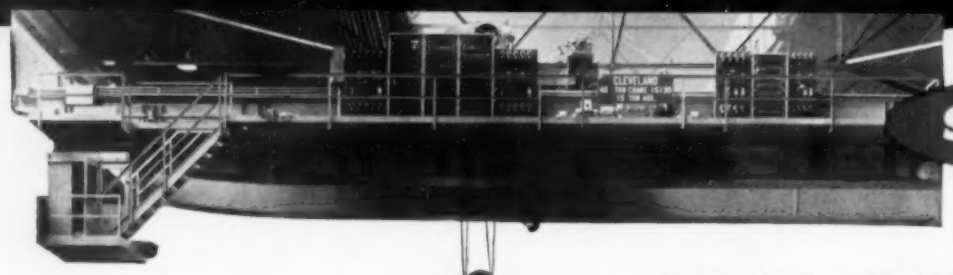
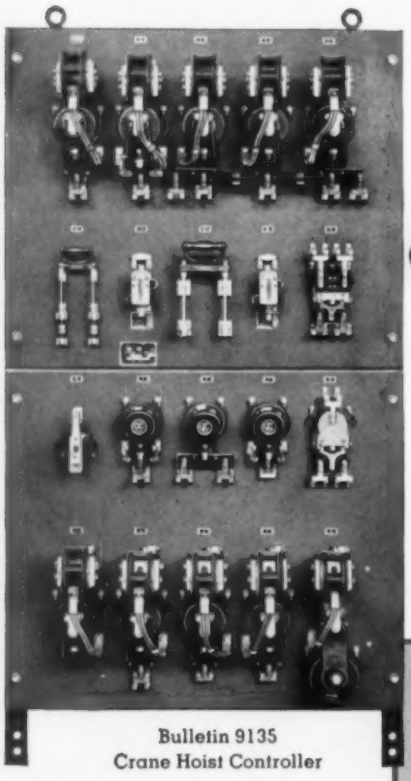
SIMPLICITY and STABILITY
....the keynote to
CLARK DC CRANE CONTROL SUPERIORITY



SIMPLICITY

Though the use of the exclusive CLARK Vari-Time principle on DC Crane Control, 3 separate Timing Relays are eliminated in CLARK Reversing—Plugging Bridge and Trolley Control.



Bulletin 9135
Crane Hoist Controller

STABILITY

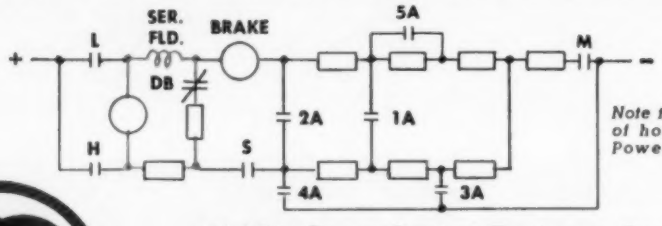
A single, simple relay of rugged, heavy mill-duty type design and construction gives fast, accurate reversing and plugging. Smooth, dependable, efficient operation results—with more protection for motors, minimum maintenance and less down time.

Bulletin 9136
Crane Bridge and
Trolley Control

AVAILABILITY

Standard Panels as shown are available for Traveling Overhead Cranes. Engineered Panels for large Coal Bridges, Ore Bridges, etc., are CLARK Specialties.

SMOOTH ACCELERATION plus SAFE DYNAMIC BRAKING on the Hoist are the ideal combination for outstanding crane performance.



Note the simplicity of hoist circuit in Power Diagram.

***CLARK** Crane Control Engineers Are Yours to Command*

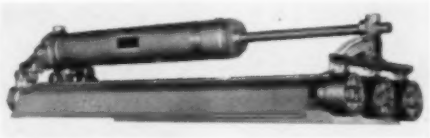
THE CLARK CONTROLLER CO.

ENGINEERED ELECTRICAL CONTROL • 1146 EAST 152ND STREET, CLEVELAND 10, OHIO

an individual tube of heat-resisting glass. The tube ends are reversed tapered and sealed into cast aluminum housings which also contain the lamp receptacles.

The receptacle housings at the ballast ends are pivotally connected to the ballast housing. At the relamping ends, the receptacle housings are fastened to a supporting stem assembly which is attached to the ceiling or a structural building member.

Fixture's reflectors are accurately formed sheet metal of interior white enamel and exterior aluminum finishes. Securely attached by spring clips, they easily may be inserted or removed after the fixture has been hung.



End-to-end placement of the fixture on close centers to other fixtures of its same type (EVF) is no handicap. A link member that is part of the supporting stem assembly allows the relamping end of the fixture to be lowered several inches for easy access without interference by adjacent fixture.

To relamp, the relamping end of the fixture is lowered by unlocking the link member, after which the threaded receptacle covers are removed. Removal of these covers exposes the lamp receptacle and mounting plate assemblies.

Tools are unnecessary to release lamp receptacle and mounting plate assembly, which is locked into the housing by a bayonet joint. A slight twist of the wrist locks or unlocks it.

Type EVF fluorescent lighting fixture is regularly available for straight pendant mounting but special fittings for 45-degrees mounting are also obtainable.

FORK LIFT TRUCK

▲ Development of a new 30,000 lb capacity "Traveloader" — unique combination side-loading fork truck and load carrier — designed for use in steel mills and warehouses to speed the handling of flat or coiled steel stock, has been announced by Baker-Raulang Co.

The truck is a self-loading unit which picks up loads from the side, hauls them lengthwise within the

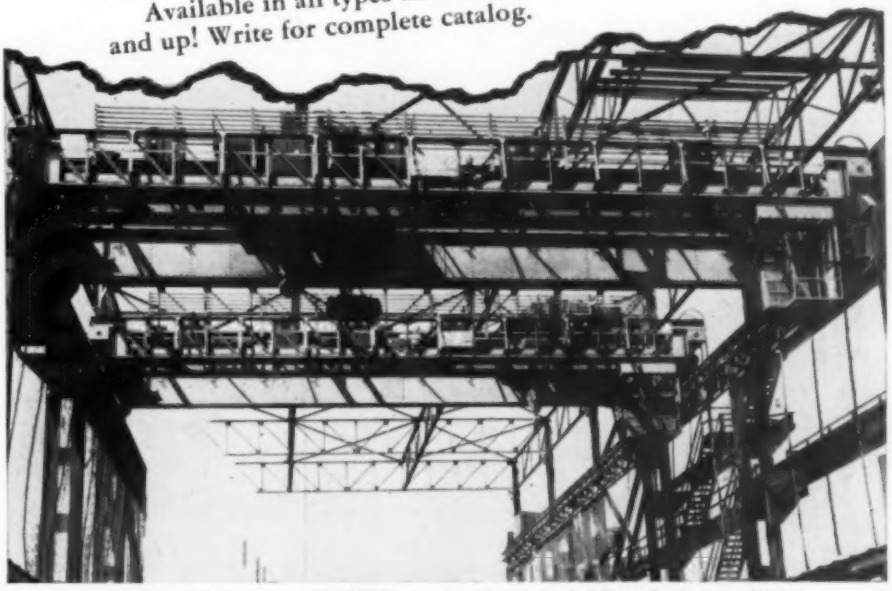
30 ton 89 foot span BEDFORD Magnet Crane over the slab yard in the new Portsmouth, Ohio, mill. Other new Bedford Cranes have been installed in the open hearth stock house, blooming mill slab yard, cinder yard and the mould yard.

DETROIT STEEL INSTALLS SEVEN NEW BEDFORDS

More and more steel men are comparing—and choosing Bedford Cranes for advanced design—for precision engineering—for safe, smooth, dependable performance.

Backed by more than 50 years of specialized crane building experience—each Bedford Crane is custom engineered for its specific application.

Available in all types and sizes from 5 tons to 350 tons—and up! Write for complete catalog.



Two 30 ton 75 foot span BEDFORD Magnet Cranes with 15 ton bucket auxiliaries over the cinder yard—used as skull cracker cranes in the Portsmouth, Ohio, mill.

BEDFORD CRANES SERVICE

STEEL MILL CRANES

BEDFORD

BEDFORD FOUNDRY & MACHINE COMPANY, INC. - BEDFORD, INDIANA

Designed for speedier handling of flat or coiled steel stock, this side-loading truck permits safe operation at speeds up to 30 mph.

width of the unit and stacks them parallel to aisles. It requires much less aisle-width to operate than conventional fork trucks of the same capacity, and — because loads are carried inboard, on the load deck — provides an unusually high stability factor which allows safe operation at speeds up to 30 mph.

When it stacks or unstacks, the truck gains added stability through the use of hydraulically-operated stabilizing jacks, controlled from the driver's seat. One man controls the entire operation from his driving position, with unobstructed visibility on all sides of the unit.

Along with its ability to operate in narrow aisles and move loads at high speeds, the new Baker-Raulang truck offers another advantage over conventional fork trucks for steel handling work: it is pneumatic-tired and can be used for long hauls over relatively unimproved surfaces—even intra-city trips.

In yard handling applications, this feature eliminates the need for separate equipment to stack and haul; the truck does both jobs efficiently.

A conventional fork carriage is provided for handling flat loads; a ram attachment is available for coil handling.

Hydraulic steer is provided as standard equipment on the 30,000 pound capacity Traveloader.

STEAM CLEANER

▲ The new "JO Hypressure Jenny" steam cleaner, manufactured by Homestead Valve Mfg. Co., features maximum utility through easy movement on its 16 in. × 4 in. rubber-tired wheels, and extra-heavy-duty welded steel chassis. Road-building and construction contractors, factories, hatcheries, poultry, livestock and dairy farms will find this new unit particularly useful, because of its ability to roll over rough ground. Its nozzle control system is said to save fuel, chemicals, water, and time by permitting the operator to start and stop the unit at the cleaning job, 100 ft or more from the Jenny. Only three simple steps are necessary to start or stop the unit; and from a cold start, a full-powered blast is delivered at the cleaning gun in less than 90 sec. High controlled pressures, the right amount of water, and a wide choice

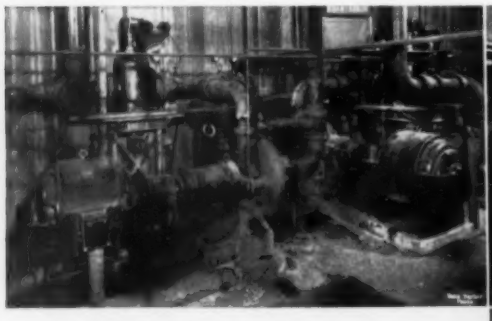
of concentration of cleaning solutions at the nozzle make the cleaner 10 times more effective than ordinary cleaning methods. Its vapor spray output is 90 gph; but the unit is also available with 120 gph output. A zippered canvas machinery cover protects the unit against weather.

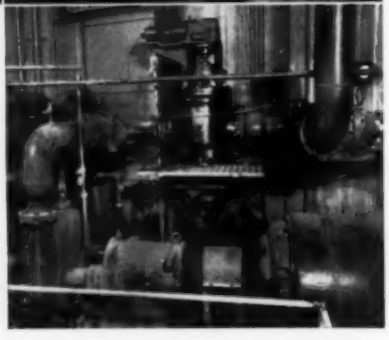
HANDCLEANER

▲ Dacar Chemical Products Co. has developed a jellytype handcleaner, which dissolves and removes any grease, soil, paint, tar, etc., from workmen's hands by simple rubbing of same over the skin for several seconds.

The cleaner can be wiped or rinsed off the hands, leaving the skin exceptionally clean and velvety soft.

Only a small quantity is required for cleaning and the compound contains lanolin. The material possesses no odor, nor is an odor detected on





AT UNION POWER CO.'S VENICE, ILL. POWER PLANTS

13 Nagle Pumps HANDLE THE TOUGH JOBS

Eleven 8" type "T" horizontal shaft pumps handle abrasive fly ash and water—A 4" and a 1" type "SW-OB" vertical shaft pumps handle pumping of river water and gritty drainage. Many power plants—and other plants with abusive pumping conditions—have found Nagles both efficient and ultimately economical. Send for "Nagle Pump Selector".

NAGLE PUMPS

NAGLE PUMPS, INC.
1263 Center Ave., Chicago Heights, Ill.

PUMPS FOR ABRASIVE AND CORROSIVE APPLICATIONS

ROBINSON
PIPE CLEANING CORPORATION

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CANONSBURG, PA.

MILL SHUTDOWNS
caused by sewer obstructions
CAN BE AVOIDED

ILLUSTRATION OF DEPOSITS REMOVED FROM 5 FT. DIA. SEWER.

250 TONS OF MILL SCALE AND DEBRIS REMOVED FROM 500 FT. LENGTH OF 5 FOOT SEWER

(Salvage Of The Mill Scale More Than Paid For Sewer Cleaning Price)

SEWER CLEANING - WATER AND GAS LINE
CLEANING AND HOT BLAST STOVE CLEANING

the market. A sample can be obtained on request and product is packaged in one pint, one gallon and five gallon cans.

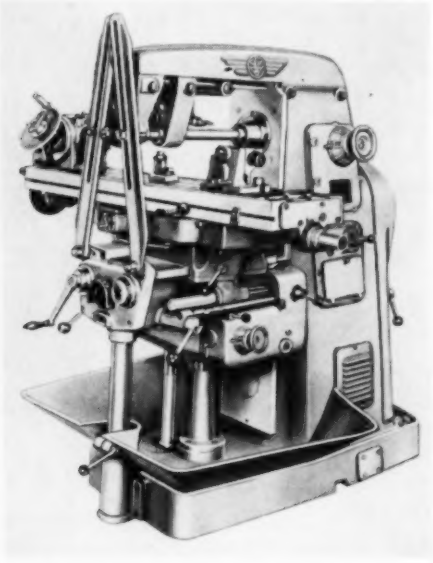
BELT CAPPING

▲ The mechanical goods division, United States Rubber Co. is adding a tough rubber capping along the edges of conveyor belts used on underground coal equipment to give them longer service life.

Field experience has shown that the edges of the underground belts receive extremely severe punishment in coal mining service. Often belt edges will wear through the rubber cover to the inner belt fabric. When this happens, moisture and fine coal particles enter the fabric and cause rapid belt deterioration. The new capping, used on the U. S. Giant conveyor belts, is an extra layer of rubber of special construction which guards against excessive wear.

MILLING MACHINE

▲ Hercules No. 2 precision milling machines, manufactured in Denmark by an old established builder, are built to American standards and are equally well suited for tool room work as for production. Plain, universal and vertical types are available and all feature a sliding support column for front end of the knee, which can be clamped in any position for increased rigidity. Hardened and ground gears are used throughout, and the milling spindle runs in adjustable roller bearings. Column and knee ways are also hardened and ground.

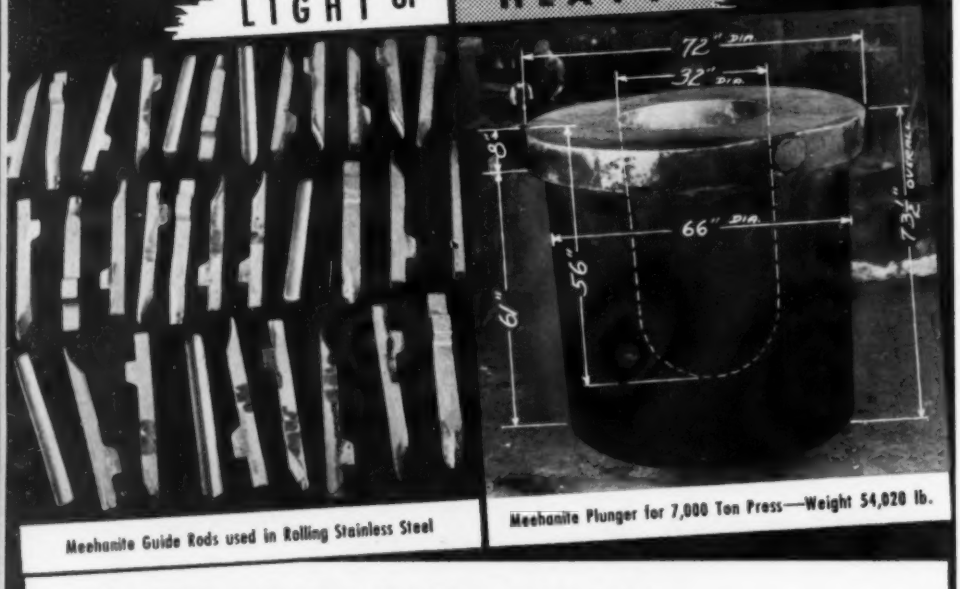


Machines are equipped for power rapid traverse in all three directions and the table feed and rapid traverse are all controlled by a single lever. Electro-dynamic braking provides quick stopping action. Weight of the table, saddle and knee is counterbalanced by a heavy coil spring inside the support column.

The machines also feature automatic lubrication by separate built-in oil pumps. Another extremely useful and novel feature is the arrangement of the drive to the spiral dividing head which permits rotation of the dividing head spindle while the table is at rest. This permits milling of ring grooves, bayonet lock grooves and similar shapes. Milling spindle has American standard spindle nose No. 50 and the all-important front bearing is of the double row, adjustable roller type, SKF-HN3015K. All feed dials read in .001 in.

ROSEDALE CASTINGS CAN HELP YOU SOLVE *YOUR* PRODUCTION PROBLEMS

LIGHT or HEAVY



Meehanite Guide Rods used in Rolling Stainless Steel

Meehanite Plunger for 7,000 Ton Press—Weight 54,020 lb.

MEEHANITE QUALITY CASTINGS as manufactured by Rosedale Foundry & Machine Company can help you solve problems involving

- GENERAL ENGINEERING
- HEAT RESISTANCE
- CORROSION RESISTANCE
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Each Rosedale Casting reflects 75 years experience in quality production. As one of the earliest foundries in the United States to adopt the Meehanite processes you can be assured of the best in "engineered" high property castings.

ROSEDALE FOUNDRY & MACHINE CO.

1731 PREBLE AVENUE • PITTSBURGH 33, PA.

Telephone Cedar 1-4007

Special accessories available include various types of vertical milling attachments, rotary table with or without power feed, slotting attachment and rack cutting attachment.

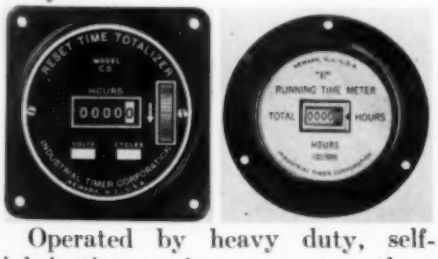
Parker Machine Co., Inc. is the American distributor.

TIMING UNITS

▲ Industrial Timer's new model C5 reset time totalizer incorporates a special type of reset counter that permits you to reset to zero at any time. It has a range of 10,000 hours, counts in 1/10 hours. It can be supplied for 115 or 220 v operation at 60, 50 or 25 cycles. Model C5A, supplied for the same voltage ratings, has a range of 100,000 hours, counts hour units.

Heavy duty synchronous motors, self lubricated for long life, are connected through gears to 5 digit counters that record the number of hours or minutes in use, depending upon the model selected. Units are mounted in steel housings with baked black finish — have terminal connections on back. Housing measures 2⅞ in. in diameter, 3¼ in. long. Heavy steel mounting flange measures 3¼ in. × 3¼ in. Also available as open type meters in Models C7 and C7A, which provide the same ranges and ratings as the C5 and C5A respectively.

Industrial Timer's Series C2 running time meters can now be obtained with ranges of 10,000 or 100,000 hours, counting in 1/10 or 1 hour units; and with ranges of 10,000 or 100,000 minutes, counting in 1/10 or 1 minute units. They can be supplied for 115, 220 or 440 v operation at 60, 50 or 25 cycles.

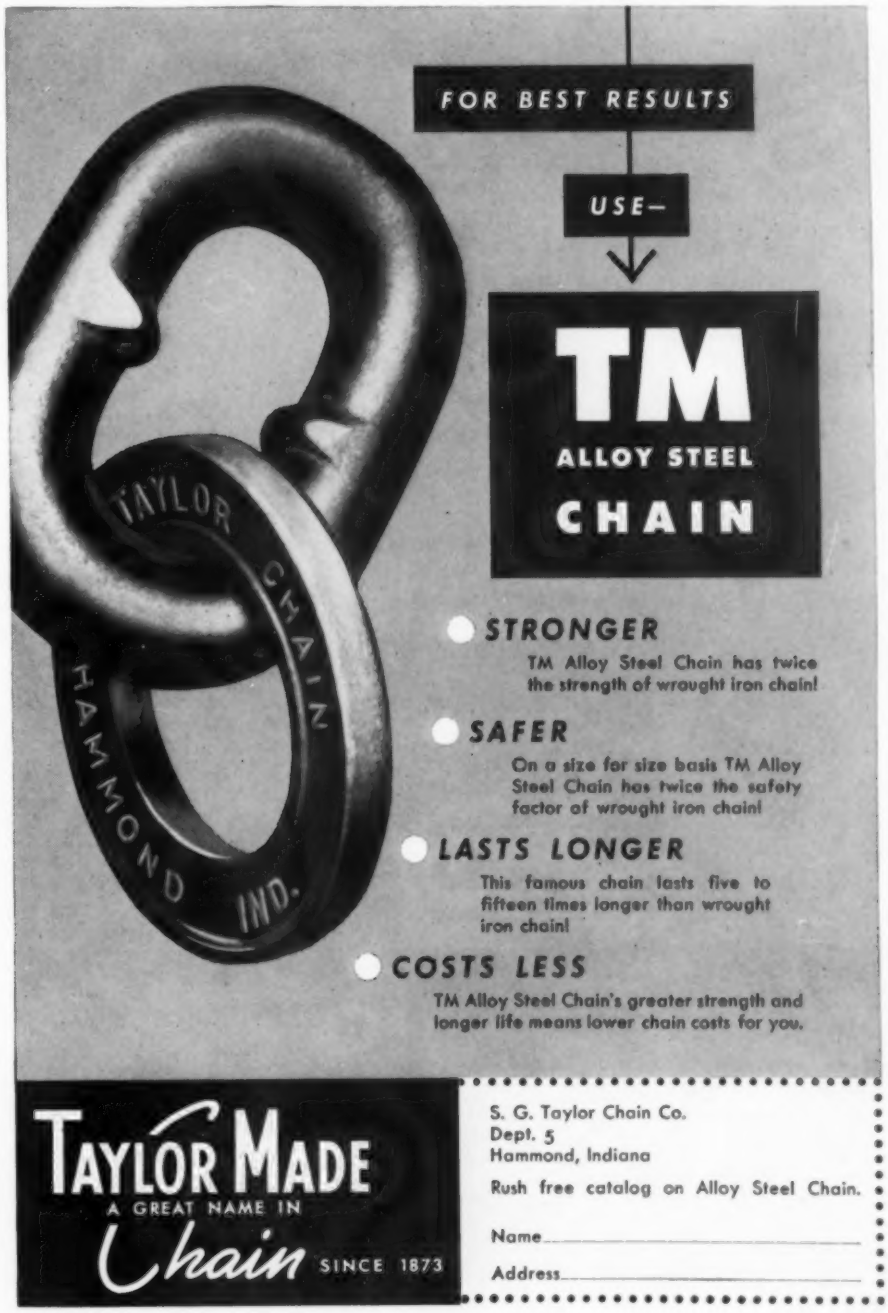


Operated by heavy duty, self-lubricating synchronous motors, these meters are completely enclosed to seal out moisture and dust, thus assuring long life and perfect operating efficiency. Units are housed in 3½ in. black bakelite meter cases requiring 2⅞ in. panel mounting hole. Screw terminals for wiring are on the back of the unit. Open type meters also available in the same ranges and ratings as Series C4 running time meters.

OPERATING COSTS REDUCED WITH TM ALLOY STEEL CHAIN!

The growing use of TM Alloy Steel Chain is resulting in lower chain costs everywhere, according to the S.G. Taylor Chain Company of Hammond, Indiana. Special Analysis Alloy Steel and Taylor's unique chain-making methods assure a product that has twice the strength, twice the safety factor and many times the life of wrought iron chain.

These features plus the fact that TM Alloy Steel Chain is heat-treated and never requires annealing... its resistance to shock at all temperatures... its ability to withstand work hardness and grain growth add to the success of this chain. A complete line of slings, in a variety of sizes, with a choice of alloy steel attachments is available from stock. Two types of patented magnet chain assemblies are also available. TM Alloy Steel Chain is manufactured to customer's specifications as well. Contact your distributor today or write Dept. 4, S. G. Taylor Chain Company, Hammond, Indiana.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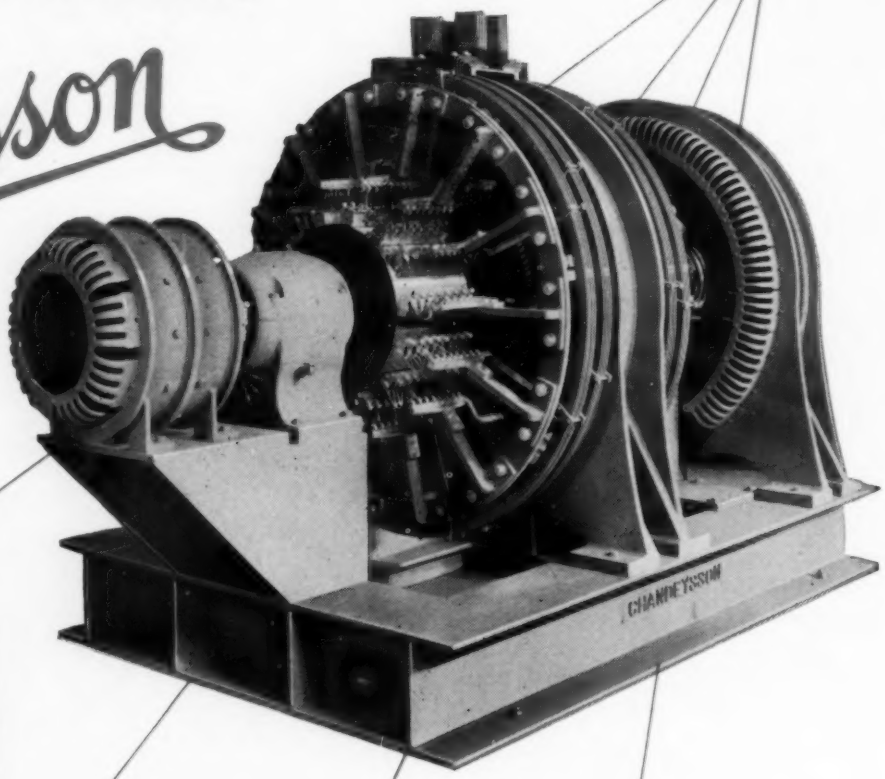
in Power Conversion for Plating with the New

Chandeysson Motor-Generator



1

USE LESS POWER...
with the overall efficiency of 85% *plus* of the Chandeysson Motor-Generator . . . savings that can mean hundreds of dollars per year as compared with other power conversion methods.

2

GET MORE OUT OF THE POWER YOU PAY FOR...
with the Chandysson synchronous motor's built-in 80% leading power factor. Shop current can be reduced as much as 11% for the same load all along the line . . . cutting your power bills . . . reducing transformer and feeder losses throughout your entire plant.

3

A LIFE-TIME INVESTMENT...
designed to pay for itself over and over again in peak efficiency service for many years to come. Original Chandeysson units are still in constant use after almost half a century of service . . . and they always have a high resale value.

4

EXTRA OVERLOAD CAPACITY...
when you need it most. Your Chandeysson Motor-Generator can carry loads far in excess of rated capacity for long periods of time, without damage to the unit. You can always depend on it in emergencies.

535

Get complete facts and figures on the overall savings made possible by the new Chandeysson Motor-Generator.
SEND THIS COUPON for your FREE copy of Bulletin D101:

CHANDEYSSON ELECTRIC CO., 4076 Bingham Ave., St. Louis 16, Mo.

Please send me, without obligation, a free copy of Bulletin D101.

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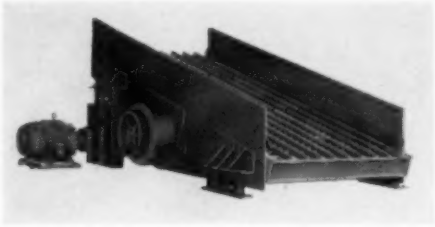
SCALPING SCREEN

▲ Link-Belt Co. has announced a new heavy duty scalping screen for fast economical scalping of ore, rock and similar materials.

These screens have massive decks formed with a combination of wide flanged "H" beams and deep section ship channels, stress relieved for maximum strength and freedom from distortion. The rugged deck is designed to handle the high impact of large boulders.



A full floating vibrator mechanism, completely enclosed for operation under severe dust conditions, permits the screening of extremely high capacity of sticky ore with maximum efficiency. Screen movement is easily adjusted by varying the amount of segmental weights.

Automatic controls limit motion during acceleration and deceleration, thereby eliminating excessive vibration during resonance.

Large helical springs isolate vibration from foundations, concentrating vibrating motion in the wide deck for thorough action of the deepest bed.

Maintenance is simplified by making the bearings readily accessible. Hydraulic bearing removal further decreases maintenance time.

Deck can be furnished either with grizzly or heavy perforated plates with riding bars.

REVERSAL UNIT

▲ Automatic reversal of open hearth furnaces is now being accomplished by a multiple-record electronic instrument made by Foxboro Co. The instrument, a multi-record "Dynalog" recorder with specially designed Rotax electric control features, uses temperature measurements, by thermocouple or radiation units, as the basis for furnace reversal. The use of an easily-filed circular chart, with each record in a different color, facilitates a daily check on operating conditions. Additional records of stack and steam temperatures, up to a total of six records, can be provided on the same chart. Bull's-eye lights can be mounted on the instrument or the panel to indicate direction of firing.

Reversal is initiated by either of two conditions: first, when the temperature difference between the two checkers reaches a pre-set value, or second, when the temperature at either checker reaches a pre-set maximum.

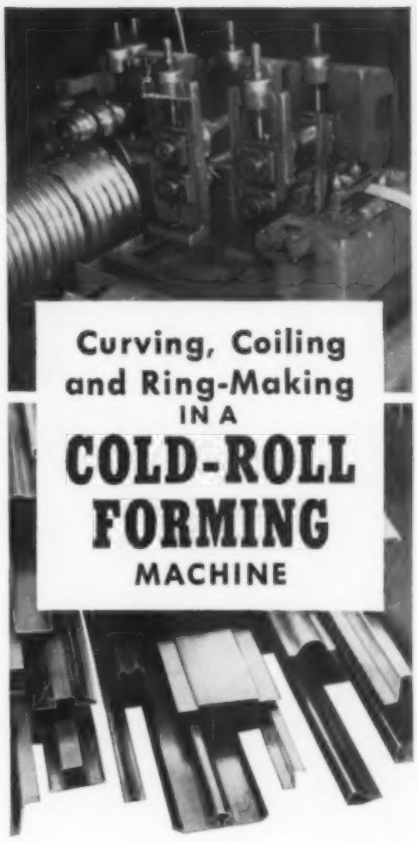
Reversal by temperature difference allows reversal time to be a function of the temperature of the waste gases, thus helping to keep the regenerative system in balance. An external setting knob on the recorder permits the furnace operator to adjust the temperature difference setting when shorter reversal periods are desired toward the end of the heat.

High temperature reversal provides an override control, operating directly from an electrical contact which is actuated by checker chamber temperature. This safety feature prevents a checker chamber from reaching an undesirable high temperature, the reversal occurring independently of the temperature difference between the two chambers. Warning alarms can be furnished to alert the operator.

A timing reversal system can also be interwired so that automatic reversal can be actuated by the preset temperature difference, elapsed time, or high temperature, whichever occurs first.

PORTABLE POSITIONER

▲ The James Campbell Smith Co., Inc. announces the availability of its 'safety-engineered' "Gonser" portable positioner. After five years of "on the job" testing in the nation's leading industrial plants without a failure or slippage, this versatile positioner will now be nationally dis-



CURVING and coiling to almost any diameter, are two out of many operations which can be performed in a Yoder roll forming machine. As fast as formed, the sections can be continuously coiled and cut to length to make rings for auto hub caps, headlights, wheel trim, stator rings, etc., at a huge saving in cost of materials and labor.

Among other operations which can be tied in with cold roll forming may be mentioned embossing, notching, perforating, welding, flattening, lock-seaming, filling and closing tubular shapes, wrapping, edge trimming, etc.

In the design and assembly of production lines of this character, the know-how of the Yoder engineering staff is at your service. The Yoder book on Cold Roll Forming deals broadly with the most important phases of the subject. Ask for it.

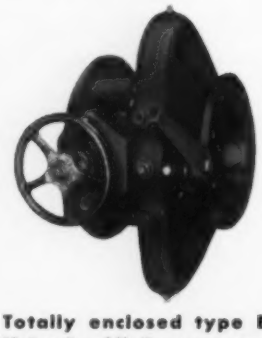
THE YODER COMPANY
5495 Walworth Ave., Cleveland 2, Ohio

Cold-Roll FORMING MACHINES
ENGINEERING YODER MANUFACTURING

GOGGLE PLATE FREES *Instantly*

REGARDLESS OF TIME BETWEEN OPERATIONS

60" x 48" Bailey Valve for horizontal gas main.



Totally enclosed type Bailey Valve for 6" diameter gas main.

Bailey Mechanical GOGGLE VALVES

No matter how long they remain unused, you can count on these valves to provide the tight, positive seal needed for shutting off gas mains in emergencies or for repairs. Requiring a minimum of maintenance, Bailey Mechanical Goggle Valves operate by a powerful clamping force which is applied equally to all points around the disc periphery. The goggle plate is freed by the same powerful mechanism. The safety and dependability of these valves have been thoroughly proved in service in gas washers, gas mains, coke plants and boiler plants. Available in sizes from 6" to 72", totally enclosed if desired.

WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD PITTSBURGH 16, PA

tributed through manufacturers-jobbers.

Designed for lifting plates, weldments, castings and all heavy machinery and equipment the portable positioner is a special purpose tool that combines wedge, screw and toggle to form a powerful and safe gripping unit. Its special construction and steel used in the frame gives flexibility for gripping and strength for the load. The Gonser positioner lifts its load into any desired position and can remain clamped on while it goes through any number of operations saving time and increasing efficiency. This versatile tool eliminates chains, pry bars, ropes, eye bolts, blockings and "C" clamps.

Self-aligning heat treated grip cups with knife sharp edges that cut through paint, grease, rust, scale and oil is the secret of its complete safety.

Its long shackle allowing for 360 degree movement giving wide-range positioning is one of the reasons for the versatility of the tool.

The portable positioner is cadmium plated for visibility, cleanliness, rust proofing and long life.

STRADDLE TRUCK

▲ A "Warehouser" electric rider-type straddle truck which permits 4½ degree backward tilting of loads without affecting unit load capacity has been developed by the Yale Materials Handling Division, Yale & Towne Manufacturing Co.

As the load is raised on this new straddle truck, it is tilted automatically by a cam on the upright channels. A hinge at the top of the carriage permits the action. Backward tilting insures great load stability and is particularly desirable with lightweight or awkwardly shaped loads or for use on rough floors.

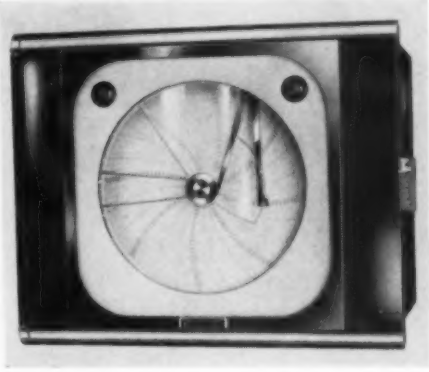
Yale's straddle truck was especially designed for narrow aisle operation and can right angle stack in aisles six feet wide or less. The truck is extremely well suited for older type buildings with limited floor load and elevator capacities.

A single lifting cylinder allows the operator a clear view of fork and outrigger tips for close operations. The truck has a dead man safety control treadle which instantly cuts off power and applies the brake when the operator leaves the truck.

PROGRAM CONTROLLER

▲ Bristol electronic dynamaster recording potentiometers are now available in the form of time-temperature program controllers, according to an announcement by Bristol Co.

These new program controllers regulate temperature according to a predetermined schedule of changing values. Any desired program, such as a heating, soaking, and cooling cycle can be accurately maintained. The desired schedule of temperatures is



prescribed by the contour of a transparent plastic cam. The same controller can be used to maintain any number of different temperature programs, since cams of different contour are easily cut and interchanged. The instruments employ an electronic control system with proportional input action optionally available.

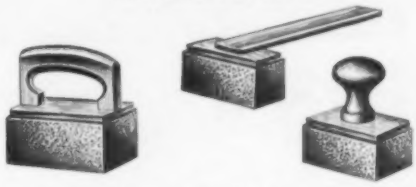
SAFETY SWITCH

▲ The first NEMA XII safety switches, a complete line of devices in special industry enclosures, have

MARTINDALE

COMMUTATOR MAINTENANCE EQUIPMENT

COMMSTONES



Manually held Commstones made in a variety of sizes and with various handles. Eight grades available for proper resurfacing of commutators and slip-rings.

TYPE "C" COMMSTONE HOLDER

Holds Commstones rigid and true for concentric resurfacing of commutators and slip-rings while running at normal speeds in their own bearings. Grinds commutators up to 4¾" wide. Used with two Commstones in stone holder or one Commstone in 2" box.

MICA-MILLER UNDERCUTTER

A powerful, light-weight, low cost, easy to use Undercutter, operating from 1/5 h.p. Universal motor. Available with small, medium or heavy-duty head (interchangeable). Also available with air motor or flexible shaft drive.

Write for new Catalog No. 29 of Electrical, Industrial and Maintenance Equipment.

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been announced by the Square D Co. This special industry switch has been introduced to meet the needs of the machine tool and processing industries as well as the industrial plants requiring a switch enclosure which will exclude dust, dirt, oil, and coolants.

The box is formed and welded from heavy code gage steel. The cover is sealed by a neoprene gasket (see cutaway illustration), and is held closed by a latch and captive screws. A full cover and operating mechanism interlock is also a quality feature. External mounting feet eliminate the need for leaking mounting holes within the enclosure. No conduit openings or knockouts are provided, each installation being "tailor-made." The switch and mechanism is Square D's heavy duty visible blade line with magnetic blowout plates, non-tracking insulation, heavy silver plated copper parts, pressure fuse clips and a true quick-make and quick-break operating mechanism.

Switches are now in production in 30, 60, 100 and 200 ampere ratings in either 240 volt a-c/250 volt d-c, and 600 volt a-c/d-c.

REVERSAL SYSTEM

▲ A new packaged automatic reversal system for open hearths, regenerative soaking pits, and glass tanks has been introduced by Askania Regulator Co.

The system features a compact panel in which the reversal controls are factory-assembled. Reversal can be initialed automatically by elapsed time or checker temperature, or semi-automatically by pushbutton, as desired.

The Askania system provides unvarying reversal sequence, with all

steps electrically interlocked for safety. Fast reversal and better utilization of checker heat mean greater furnace efficiency. Panel lights indicate firing conditions and reversal sequence. Pistol-grip switch gives operator control.

COPYING UNIT

▲ A small, low-priced office copying machine to bring the speed and savings of direct copies within easy reach of every office is being introduced by Ozalid, a division of General Aniline & Film Corp.

The "Bambino" is specifically designed and priced for small volume users. Only slightly larger than the ordinary electric typewriter, the machine has all the advantages of the regular Ozalid models designed for companies who need more printmaking capacity.

The new machine will copy letters, accounting statements and reports, purchase orders, bills of materials — anything, in fact, that is written, typed, printed or drawn on a sheet of translucent paper up to 9 in. wide, any length. A first copy is ready in seconds; up to 200 copies can be made in an hour.

Cost of the unit is $325, plus taxes —far less than any comparable machine. Letter-size Ozalid copies cost less than 1½¢ each, including labor and materials. Thus, by eliminating

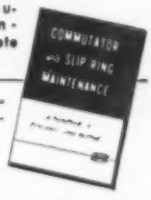
Keeps motors running like new... The easy, fast way to restore commutators and slip rings — WITHOUT DISMANTLING! — Substitutes low-cost prevention and correction for high-cost repair and rebuilding — COSTS LITTLE, SAVES A LOT.

RESURFACERS
Refinish commutators and rings to like-new condition even when ridged, scored or burned.

MICA UNDERCUTTERS
Stop sparking — help commutation — prolong brush life. For all sizes of commutators.

PRECISION GRINDERS
For more than surface smoothing—under machine's own power. Accurate to .001".

FLEXIBLE ABRASIVE
Cleans and burnishes commutators. Non-dusting. Complete size range.



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re-writing, typing and proofreading, the Bambino saves a firm many dollars daily in copying routine correspondence.

Specially designed for small volume uses, the "Bambino" office copying machine is capable of delivering up to 200 copies in an hour. The unit will copy anything that is written, typed, printed or drawn on translucent paper in widths up to 9 in.— the first copy being ready in seconds.

The machine will be shown in September at the American Chemical Society Meeting in Chicago, and at the Controller's Institute Meeting in Boston. In October it will be displayed at the National Business Show in New York.

PUSHBUTTON

▲ A new snap-action over-center toggle pushbutton is available from the Westinghouse Electric Corp. Consisting of two 2-point units — each with one normally open and one normally closed contact — this maintained-contact heavy duty pushbutton is a permanently assembled unit.

Although basically a 4-point unit, the pushbutton's continuous and interrupting ampere rating is the same as the standard 2-point unit: 10 amp continuous, 50 amp interrupting at 110 volts a-c and two amperes maximum interrupting at 125 volts d-c. By making proper connections, the pushbutton can be used for 3-point applications, or it can be used for 2-point service by applying one half of the unit.

Positive action of the unit — when one button is up, the other always is down — is achieved by use of the snap-action over-center toggle that mechanically interlocks the buttons.

This pushbutton is available in seven colors — green, yellow, blue, brown, gray, red, black — and in open form or in a surface-mounted sheet steel enclosure. This open pushbutton unit is approximately 3 by 3 by 4 inches.

RECLOSING RELAY

▲ An automatic reclosing relay (RC) with a built-in instantaneous trip lockout feature is available from the Westinghouse Electric Corp. Intended primarily to automatically control the reclosing operation of a circuit breaker, the RC will prevent repetitive tripping due to the action of the instantaneous trip of the protective relay. This feature is particularly desirable where feeders are sectionalized by fuse operation since the closed circuit breaker will then allow the fuse to clear the faulted feeder.

Additional external terminals provide connection to internal coils and contacts of this redesigned relay to permit its application to all types of circuit breaker control schemes. Ad-

when you CHANGE over to SPRAYING SYSTEMS descaling NOZZLES

If you want to materially reduce down time on rolling mills due to clogged nozzles, try Spraying Systems descaling nozzles. Large orifice diameter permits passage of practically all particles that ordinarily clog other types of nozzles. Spraying Systems nozzles produce an effective uniform flat spray, free of streaks, with an impinging force equal to over 96% of the maximum potential. Typical user is the Homestead District Works of U. S. Steel illustrated above. Nozzles are made of hardened stainless steel in a wide range of capacities and spray angles. Your inquiry is invited . . . write for Data Sheet 3997.

SPRAYING SYSTEMS CO.
3262 RANDOLPH STREET • BELLWOOD, ILLINOIS

Also write for Data Sheet 4516 . . . Pneumatic Atomizing Nozzles for direct spray gear lubrication.

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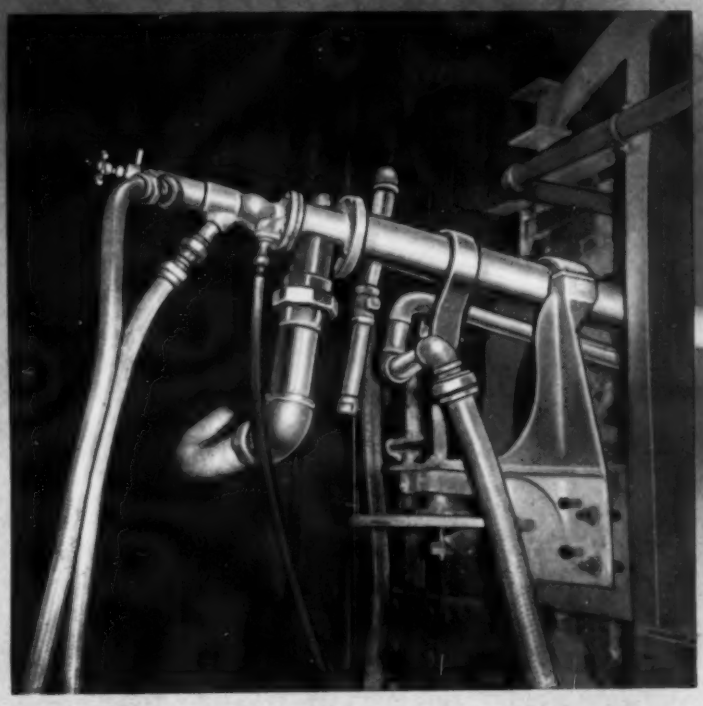
"YOUR CATHEDRAL OF FLAME"

CROWE BURNERS are the vital influence in regulating and controlling the COMBUSTION SYSTEM for both Open Hearth Production and Life.



Artillery • Water-Cooled

CROWE BURNERS

. . . FOR . . .

- **Efficient Heating**
- **Temperature Control**
- **Firing either straight oil, oil and gas, or oil, gas and oxygen.**
- **10 to 300 ton capacity**

Inside "YOUR CATHEDRAL OF FLAME" — a Crowe Burner creates an inferno of flame . . . intense . . . yet correct in length . . . when streams of fuel, air and steam rush together like a whirlpool. Regardless of the type or combination of fuel a Crowe Burner injects the fuel into a stream of pre-heated air . . . in such a way . . . as to form a flame pattern having the correct velocity . . . direction . . . and luminosity, so necessary in the open hearth process.

Because these Crowe Burners control atomization (externally adjustable) you benefit by reduced oil consumption; pressure and volume of steam.

Crowe Engineers mix the unmixables by a proven, exclusive system — eliminating doghouses and lengthening roof life in "YOUR CATHEDRAL OF FLAME"

Records are the reins that control open hearth furnace operation, but Mr. Executive, Engineer or Superintendent, are you risking the recommendation of an investment of inestimable value, by not realizing the fuel saving and additional tonnage possible, by the use of Crowe Artillery Burners and Atomizers.

What Will the Coupon Do For You?

It will help you find out how you can increase tonnage. It will bring you information on how you can increase profits substantially.

MANUFACTURED BY

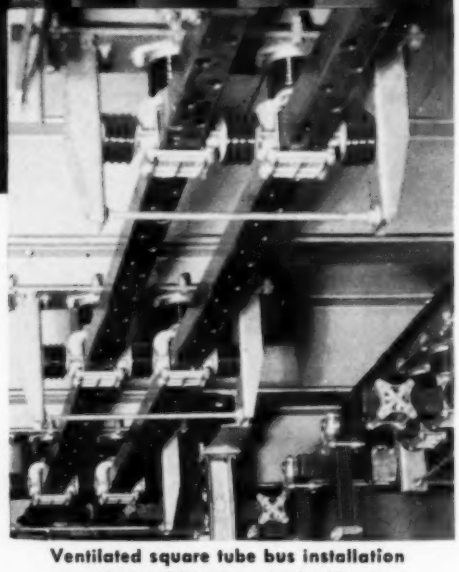
THE CROWE ENGINEERING CO.

1838 WESTERN AVE., CINCINNATI 14, OHIO

For Maximum Safety in Event of Short-Circuit

DELTA-STAR REINFORCED BUS STRUCTURES

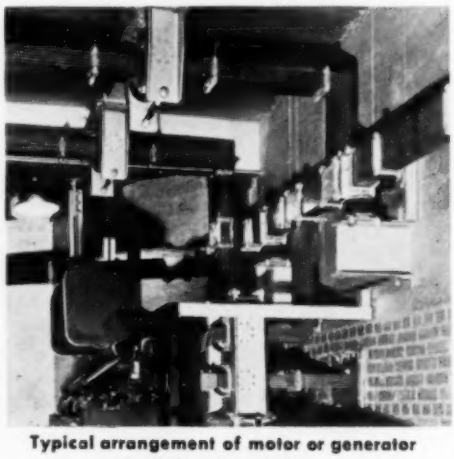
ARE INSTALLED IN MILLS THROUGHOUT THE U. S. A. AND IN MANY FOREIGN COUNTRIES



Ventilated square tube bus installation in a midwestern steel mill.

Leading steel mills have recognized the economy and security which is inherent when installing Delta-Star prefabricated reinforced bus structures. These structures are designed and furnished complete to the last detail. Careful engineering and fabrication assure a structure you can depend on to withstand the destructive forces resulting from short circuit current. Assemblies consist of heavy steel frames with high quality wet process porcelain insulators used in compression; taking full advantage of their greatest strength.

Our engineers will be glad to discuss your bus problems and work out a layout to suit your special requirements. Prefabricated open or enclosed bus structures are available for aluminum or copper bars and tubing; structural and special shapes; indoor or outdoor service.



Typical arrangement of motor or generator circuit-breaker sections.

OTHER DELTA-STAR PRODUCTS
Used in Mills and Industrial Plants

Crane Rail Supports	Water Cooled Conductors and Fittings
Disconnecting Switches	Interrupter Switches
Terminators (Potheads)	Disrupter Switches
Plugs and Receptacles	Bus and Cable Connectors
Spool Insulator Cable Supports	Outdoor Substations

DELTA-STAR ELECTRIC DIVISION

H. K. PORTER COMPANY, INC.
2437 FULTON STREET, CHICAGO 12, ILLINOIS
DISTRICT OFFICES IN PRINCIPAL CITIES

justable reclosing time sequences of 60, 90, 180, or 360-seconds are provided by a 600-rpm synchronous motor with a gear train of adjustable ratio.

The relay may also be obtained with an adjustable integrating lockout device which limits successive circuit breaker reclosures to a safe value.

The RC is available in a standard rectangular projection case or in a Flexitest case of the semi-flush or projection styles.

CARBIDE-LINED DIE

▲ A carbide-lined die that has drawn more than 5000 tons of solid steel without developing an approach wear ring serious enough to require servicing recently has been taken out of operation by the Wyckoff Steel Co.

The R-16 die was delivered by the Carboloy Department of General Electric Co. in March, 1951, and it remained in use until May of this year — a total of 26 months service — when a crack developed. The finished size at delivery was 2.4315, in a six inch tapered case. When taken out of service, the size was 2.434, an increase of only .0025.

In all, 10,420,955 lb of solid bar stock in grades F.S. 1117 and F.S. 1118 (equivalent of C-1117 and C-1118) with 1/16-inch reduction were drawn. All bars were push started with a bench speed of 65-70 fpm.

During its life, the die was never polished. According to officials at Wyckoff Steel Co.'s New England works this far exceeds the life of other similar dies and is thought to be a record for this type of operation.

The 5000 tons of steel represents 110 miles of stock — the capacity of 260 railroad cars.

PLATFORM TRUCK

▲ A two-wheel drive, four-wheel steer low-lift platform truck is detailed in a two-color folder issued by the Elwell-Parker Electric Co. The truck, Type GEP-6, is a gasoline-powered model. It has an overall length with the platform up of 125 in.; with the platform down, the overall length is 130⅜ in. The overall width is 42¾ in., the overall height measures 58 in. The platform height in low position is 10¾ in., in high position, its height is 16½ in.

The truck turns in intersecting aisles of 72 in. Travel speeds: 6½ mph with load. Lift speeds: up — 2½ seconds without load, 3 seconds with full load; down — 4 seconds without load, 1 second with full load.

The free literature devotes one page to engineering drawings which give detailed dimensions. The facing page details such operating and construction features as: speed, frame, drive axle, trail axle, lift jack, brakes, controls, motors, steerings, bearings, plus many others.

In addition, application photos show the truck handling various types of loads.

MASTER-STEER TRAILER

▲ Mercury Manufacturing Co. announces the development of a new controlled caster-steer trailer, designed to handle heavy high center of gravity loads. The caster-steering feature minimizes tipping hazards, thus assuring increased safety.

Provision of an extra long wheel base and wide tire treads, provides additional stability to this 8000 lb capacity trailer. Steering is accomplished by retractable tubular loop-handle connected by tie rod linkage between hitch and caster assembly. For greater flexibility, "C" type couplers on the rear permit its use in a trackless train system.

DISPENSING UNIT

▲ A special dispenser designed to fit jars of "Fend," barrier creams widely used to protect plant and factory workers against industrial dermatitis, is being announced by Mine Safety Appliances Co.

Depressing the plunger in the cap dispenses a small amount of Fend Cream, the MSA announcement explains. The dispensing unit is suitable for all this line of protective creams except "Fend I."

Fend Creams are popular with workers, the announcement adds, because they are bland and neutral, are compounded of cosmetically safe materials, do not interfere with normal action of skin glands, have a light "vanishing cream" consistency, and a white color and pleasant scent.

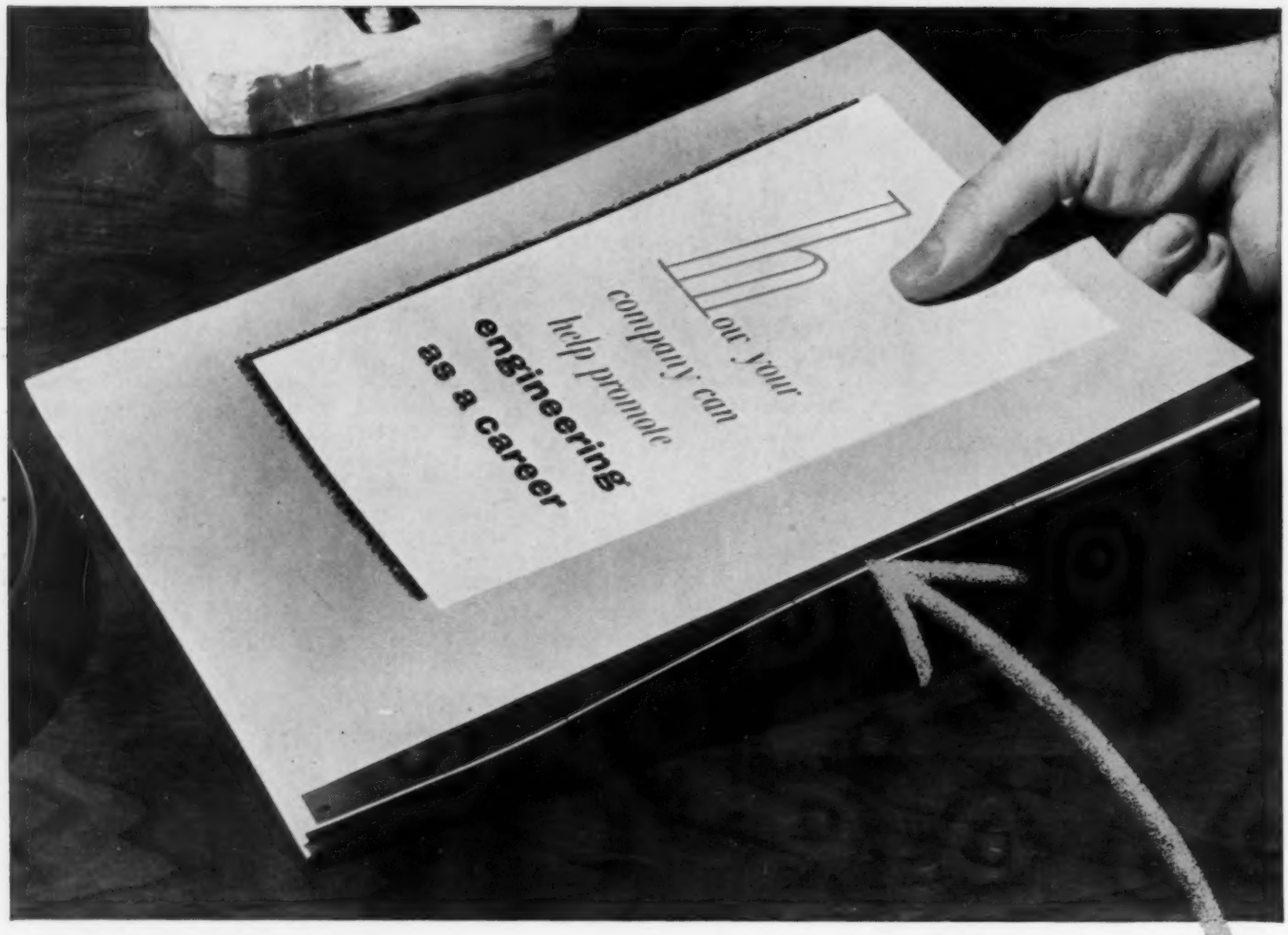
The list price of the new dispenser is 50 cents. However, one dispenser is furnished free with each dozen jars of Fend Creams and may be ordered by the designation, Part No. FC-34760.

Book Reviews

▲ **"Iron and Steel Beams, 1873 to 1952,"** the first historical record of dimensions and properties of all iron and steel rolled shapes of the past 79 years was recently published by the American Institute of Steel Construction. The publication is primarily for the assistance of architects and engineers who are remodeling or constructing additional floors to buildings erected 40 or 50 years ago, especially when original plans are not available.

Tabular data is limited to steel and wrought iron beams and columns, since other sections such as angles, channels, and tees were standardized at an early date and have been produced since without significant changes. Of interest are the unit stresses recommended by early manufacturers which will be found ultra-conservative in the light of present day recommendations. The volume

(*Please turn to page 330*)



HERE'S HELP

for your engineer-recruitment problem

Engineers' Joint Council and The Advertising Council offer free, expert help to advertisers promoting engineering as a career.

The booklet reproduced here was prepared by The Advertising Council in cooperation with the Engineers' Joint Council to help you make your advertising work most effectively in recruiting engineers for the future.

1. It tells you what the problem is and the important part you can play in solving it.
2. It outlines the advantages of an engineering career to help your company develop advertising appeals.
3. It informs you as to the current activities of industry in the education and recruitment of engineers.
4. It offers specific suggestions as to what you can do (from present manpower).
5. It provides material that you can use in your own local and national programs.

Many advertisers are using this booklet today. They say that it helps in orienting their engineer-recruitment advertising to industry-wide recruitment programs.

Send for this Free campaign guide
Prepared by
THE ADVERTISING COUNCIL
for the
ENGINEERS' JOINT COUNCIL

JUST MAIL THIS COUPON!

The Advertising Council, Inc.
25 West 45 Street
New York 36, New York

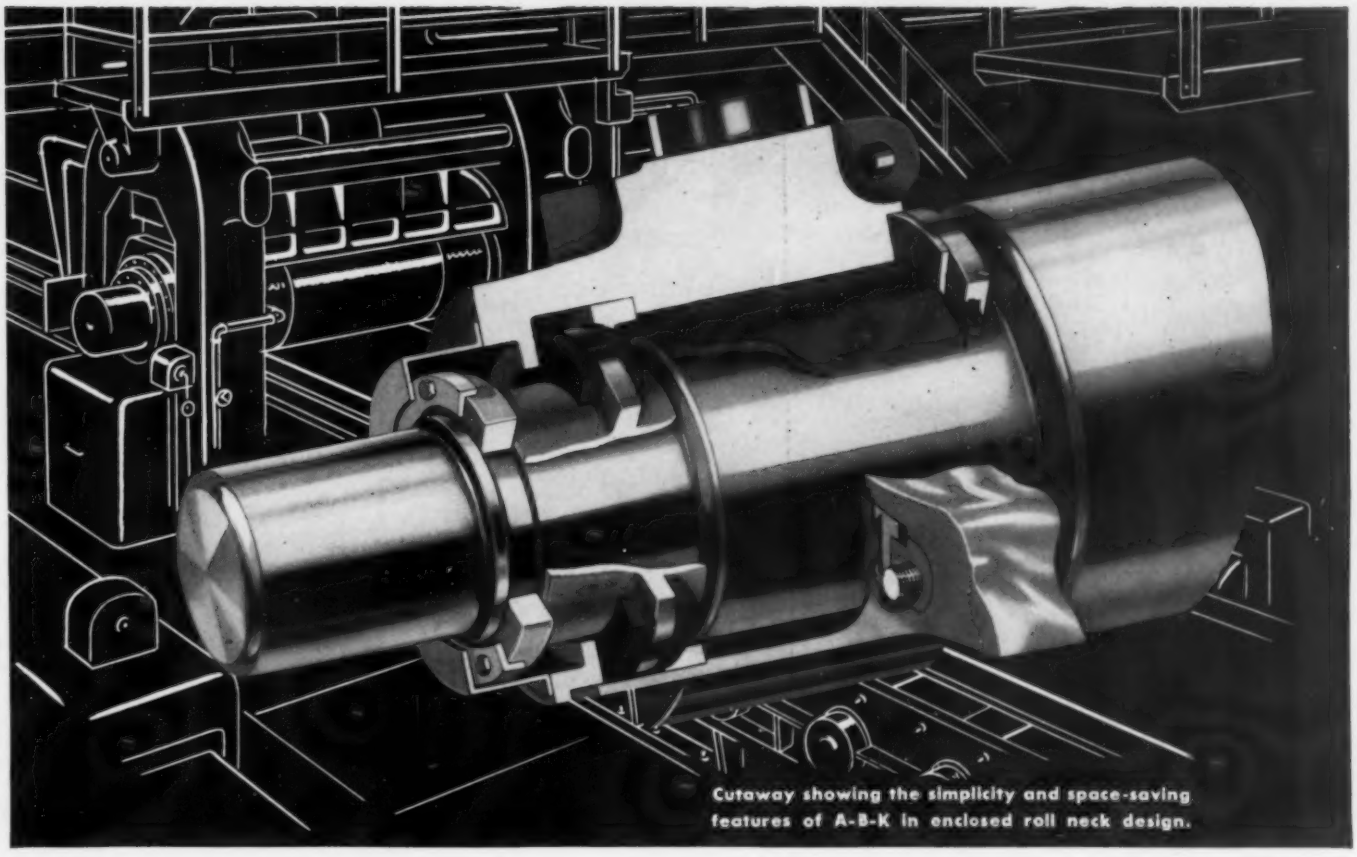
Gentlemen: Please send me a *free* copy of *"How your company can help promote engineering as a career."*

NAME: .....

POSITION OR TITLE: .....

COMPANY: .....

ADDRESS: .....



Cutaway showing the simplicity and space-saving features of A-B-K in enclosed roll neck design.

Operating Advantages of Enclosed Neck Design using A-B-K LAMINATED FABRIC BEARINGS

1. **MORE COMPACT BEARING ASSEMBLIES,** hence smaller castings and housings on original equipment.
2. **SIMPLE BEARING DESIGN,** needing fewer, less expensive parts and no special assembly equipment.
3. **LARGER NECK-TO-ROLL RATIOS,** thereby reducing possibility of roll breakage.
4. **IMPACT LOADS CUSHIONED** because of greater resiliency of nonmetallic bearings.
5. **LESS COST TO INSTALL and MAINTAIN,** are light in weight, need no special handling or protection in storage.
6. **WATER LUBRICATION** minimizes grease and oil usage.
7. **ROLL MAINTENANCE COSTS CUT,** won't score or heat check, protect roll necks.

A-B-K®
LAMINATED FABRIC BEARINGS

AMERICAN Brake Shoe COMPANY

Copyright 1953, American Brake Shoe Company

AMERICAN BRAKEBLOK DIVISION
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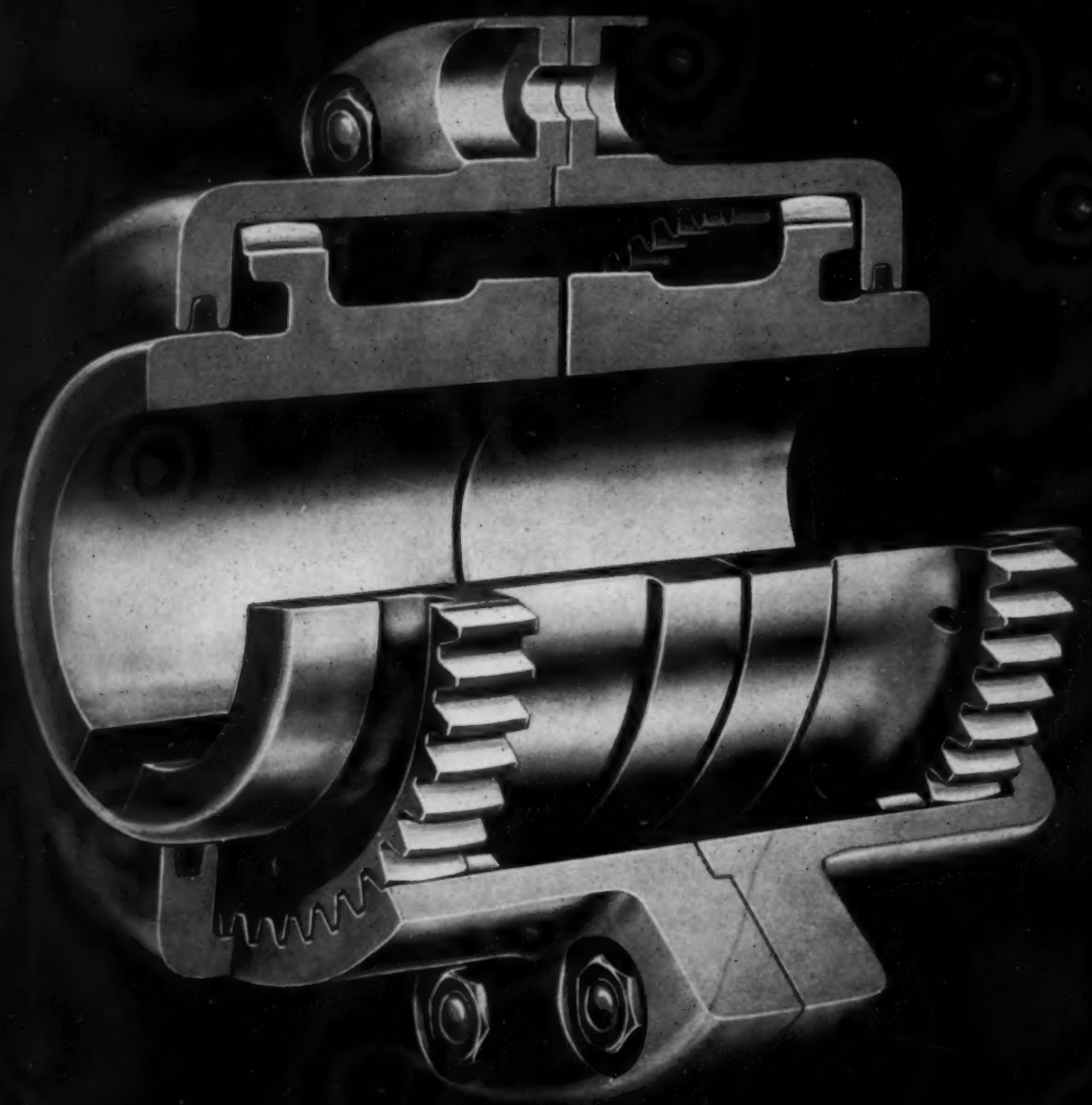
IN CANADA: JOSEPH ROBB & CO. LTD., MONTREAL, QUEBEC

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD

Annealing: Production Triples!

In this installation of three Lee Wilson radiant convector furnaces and eight bases with a charge size of 60" diameter and a piling height of 126", the tremendous efficiency of the Wilson radiant convector annealing system was demonstrated by increasing the yield from the same floor space by three times the original figure.

These units at Wallingford Steel Company at Wallingford, Connecticut are producing extremely uniform, high quality strip steel at an average production figure of 3800 tons per month. In a plant such as this where no additional space was available, this increase was achieved at a very nominal expense.

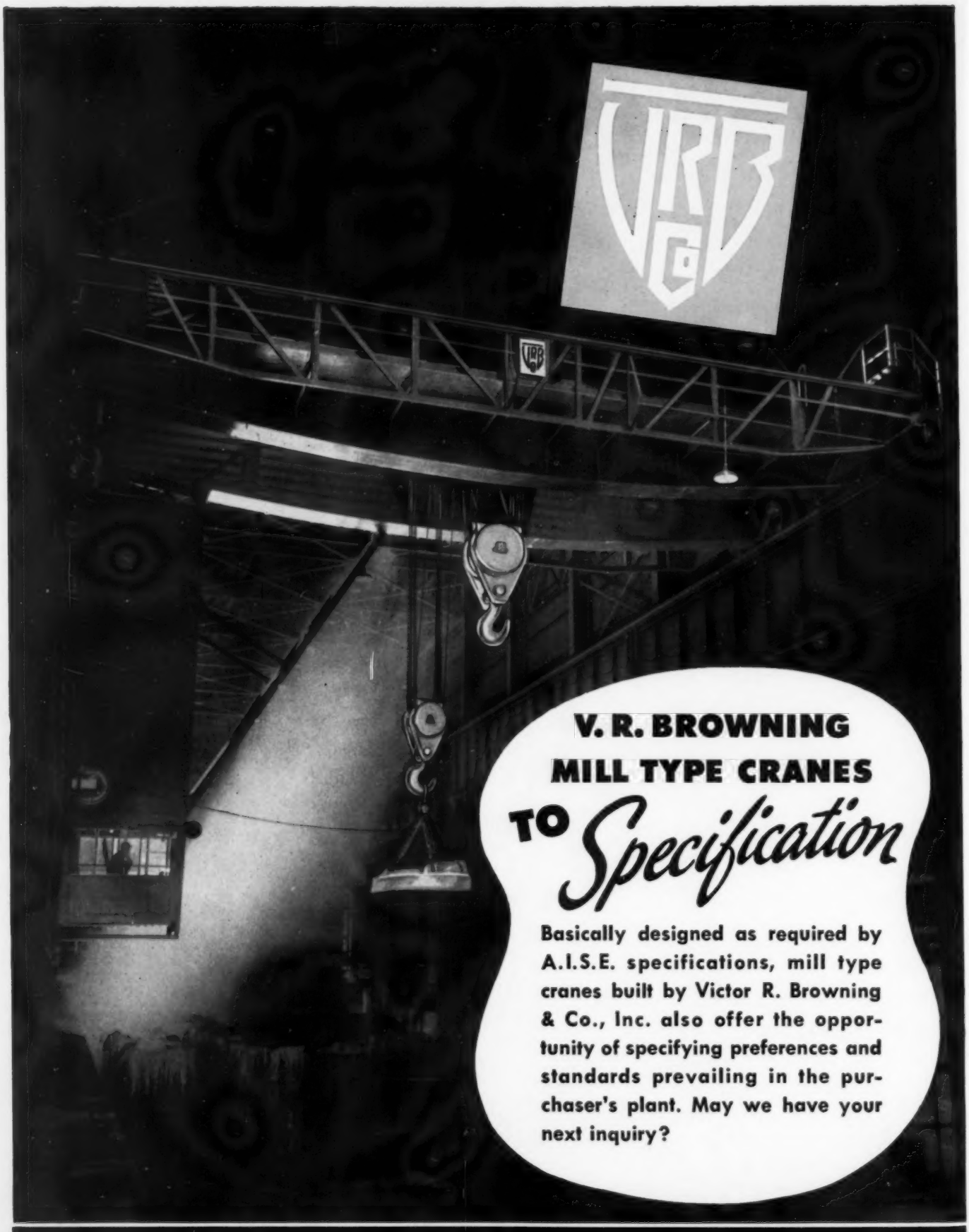
Lee Wilson

ENGINEERING Co., Inc.

20005 WEST LAKE ROAD • CLEVELAND, OHIO

Telephone ED-1-6600

BELL TYPE FURNACES • RADIANT TUBE HEATING • ANNEALING


V. R. BROWNING
MILL TYPE CRANES
TO Specification
Basically designed as required by A.I.S.E. specifications, mill type cranes built by Victor R. Browning & Co., Inc. also offer the opportunity of specifying preferences and standards prevailing in the purchaser's plant. May we have your next inquiry?

VICTOR R. BROWNING & COMPANY, Inc.

BOX 309, WILLOUGHBY (CLEVELAND), OHIO

Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

the BLOOM
TIME-CYCLE REVERSAL UNIT
for Open Hearths and Soaking Pits

THIS factory-wired, compact, cabinet-enclosed unit keeps regenerative furnaces on a uniform reversing cycle without attention from the operator—yet the firing of the furnace can always be altered, or a quick reversal effected ahead of schedule if desired by a simple push-button control. Only nine or ten seconds are required to reverse the average furnace with this unit.

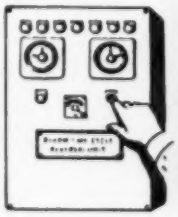
When the firing period for one end is completed, a sequence of operations begins in which fuel and steam are shut off, reversing dampers operate, and fuel and steam are admitted at the other end—all in a predetermined time-sequence that permits full and fast reversal without puffing or smoking. The Bloom Time-Cycle Reversal System is a specially engineered unit that includes: provision for operation by checker temperature as well as by time cycle, if desired; automatic "blow" and "hold" furnace operation; protection against excessive checker temperatures; full manual control of the reversal if demanded by the first helper.

We will be glad to send full information on this unit.

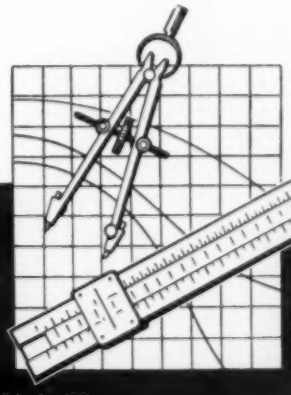
A complete, compact factory-wired and tested cabinet!

The field connections are easily and simply made—no complicated wiring is required. Each unit is completely factory-tested before shipment.

The reversal periods for both ends—North and South—are set independently, and can be changed at any time by a simple turn of the timer.



In case reversal is desired ahead of schedule, the operator merely pushes the reversal button. After reversal, furnace returns to original timing.



BLOOM
ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

"Mother's asleep now, son," Dad told him. "She'll be asleep a long, long time. It's kind of like going away. We'll have to learn to get along without her, Johnnie."

To a statistic named Johnnie

Who's Johnnie? Just one of the 175,000 children under eighteen here in the United States who have lost a mother to cancer.

Statistics are a little too big for a boy this small to understand. Even the hopeful ones about cancer—and there are more every year.

More and more today—cancer can be cured

Patients are being cured who could not have been saved—even five years ago. In 1952, some 70,000 with cancer were saved.

And this number could have been doubled, if treatment in all the cases had been begun in time.

Your contributions to the American Cancer Society helped make such hopeful statistics possible. And they can make the story even brighter tomorrow.

Not for Johnnie, to be sure.

But for all the other children—*they might be yours*—who still have their mothers and fathers. If only *one tenth* of the millions of people like you who have such good intentions would actually take the time to send us their contributions! *And would do it now—instead of turning the page . . .*

AMERICAN CANCER SOCIETY

Gentlemen:
Please send me free literature about cancer.
Enclosed is my contribution of $_____
to the cancer crusade.

Name _____

Address _____

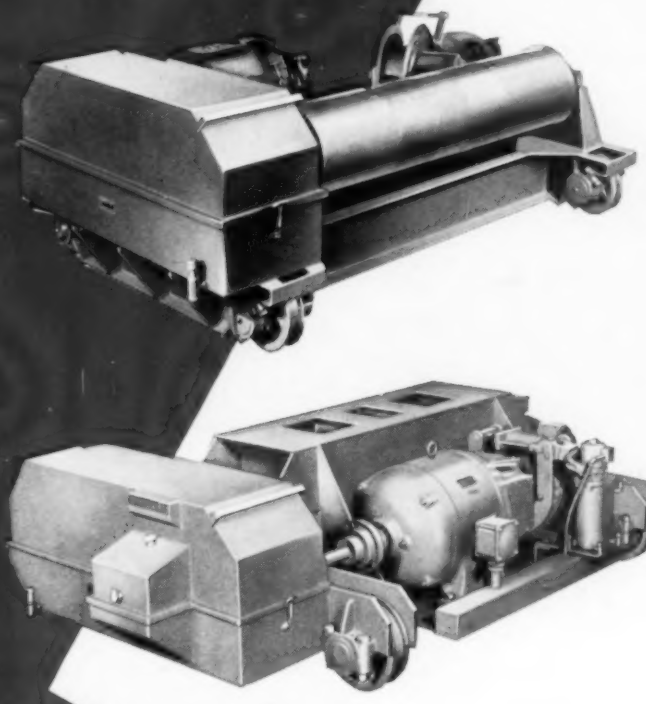
City _____ State _____

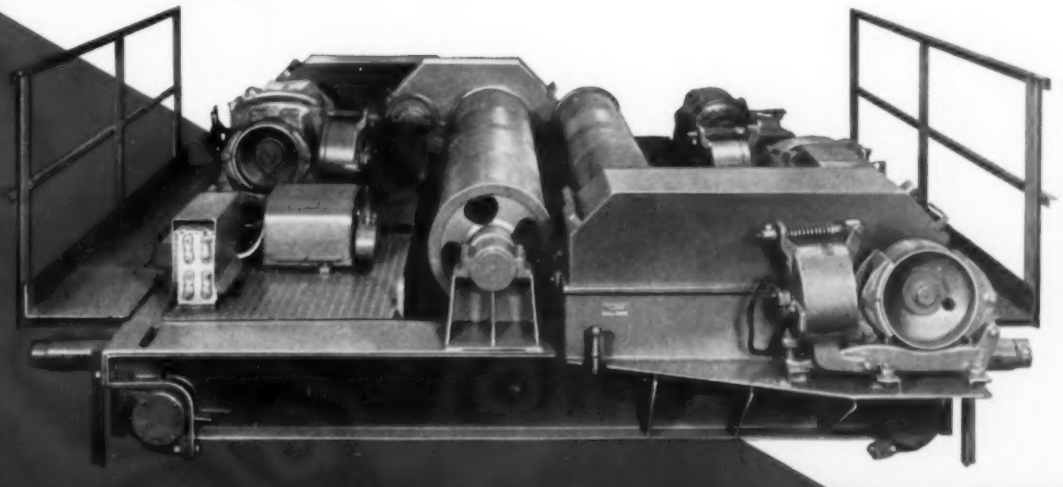
Simply address the envelope:
"Cancer," c/o Postmaster, Name of Your Town

CANCER STRIKES ONE IN FIVE

Strike back—give to the American Cancer Society

Modernize your Overhead Cranes with NORTHERN Super TROLLEYS





Your overhead crane can be only as efficient as its trolley. On its rugged strength and mechanical superiority depends the whole continuity of its operation.

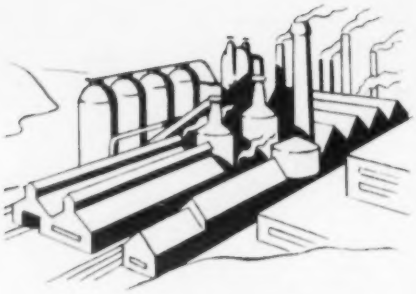
NORTHERN SUPER TROLLEYS are designed and built to withstand severe overloads and shock; to provide continuous, trouble-free operation; are constructed with all parts instantly available for inspection, and to minimize downtime for maintenance.

You can modernize your present crane with a new NORTHERN SUPER TROLLEY; find new benefits in production—new economies in maintenance—new satisfactions in dependable, efficient crane service whenever and wherever needed.

Let's explore the advantages and costs of modernizing your present overhead crane.

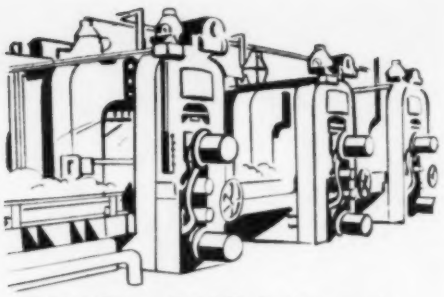
NORTHERN ENGINEERING WORKS

General Offices: 2615 Atwater St., Detroit 7, Michigan

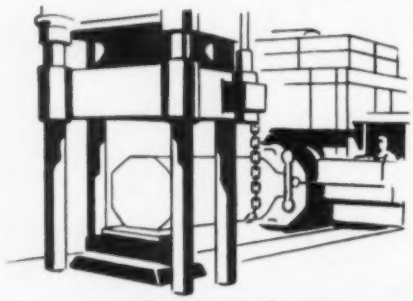


Steel Producing Plants

WHEN A *REGULAR LUBRICANT* ISN'T GOOD ENOUGH . . .



Hot Strip, Cold Reduction and Temper Pass Mills



Forging Industries

SPECIFY LEADOLENE* *Klingfast*

CHECK THESE 9 IMPORTANT FACTS:

1. **EXTREME PRESSURE pH-ilm STRENGTH** of 50,000 lbs. per square inch minimum by "Timken" testing machine.
2. **ADHESIVENESS** in which affinity for steel and other metals develops maximum adhesion and prevents drippage or creeping. Retains a flexible coating in nature.
3. **WATER REPELLENCE** which retards washing off, creates a lubricating pH-ilm under moisture or water conditions.
4. **CORROSION PREVENTION** is an excellent protective coating in that it will not etch or corrode metals. Is never acidic.
5. **COMPOUNDED STABILITY**—Will not bleed or change physical condition within range of higher than usual temperatures for this type of lubricant.
6. **LOW TEMPERATURE FACTORS**—While having a solidifying action by decreased temperature as low as —40 F., it does not harden, crack or decrease in adhesion. The flexible coating withstands distortion of the application.
7. **ABRASIVE RESISTANCE**—Extremely high for a lubricant. Does not wipe off nor will be removed in handling by workmen's hands or gloves. Is extremely repellent to adhesion of scale, metallics and other forms of dusts or contamination.
8. Klingfast has remarkable corrosive resistance to salt or sea water, acidic vapors and solutions.
9. Klingfast can be removed by ordinary solvents such as kerosene, gasolene, naphtha, carbon-tetrachloride and similar substances but is highly impervious to lubricating oils and greases.

The "I.P." LUBRICANT*

On the really tough jobs in the steel industry, the answer to vastly reduced lubricating costs and extended equipment life is *Leadolene Klingfast.* Capable of withstanding pressures up to 50,000 p.s.i., this lead-base lubricant with its "indestructible pH-ilm" has proved itself repeatedly on the most difficult applications.

For efficient lubrication in the presence of water . . . for extreme adhesiveness to steel under high heat conditions . . . for unexcelled abrasion and corrosion-resistance . . . for actual cash savings up to 400 per cent—investigate the performance characteristics of *Leadolene Klingfast.*

*I. P. . . . ("Indestructible pH-ilm" lubricant)

Write for 24-page descriptive booklet

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Since 1876

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THE ENGINEERING MART

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AN *IRON and STEEL ENGINEER* SERVICE TO THE STEEL MILL OPERATORS

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METALLIC RECUPERATORS
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For application to soaking pits, heating, and other types of metallurgical furnaces.
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REEVES—Variable Speed Drives
THOMAS—Flexible Couplings
WICHITA—Air Tube Disc Clutches & Brakes
TELSMITH—Telsmith Crushers
CULLEN-FRIESTEDT—Sheet Lifters—Welding Positioners—Track Cranes

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ACID-ALKALI-PROOF CONSTRUCTION
of pickling and other tanks; flooring.
(TEAR OUT & MAIL WITH LETTERHEAD)

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"Centralized Lubricating Systems"

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Clamshell — dragline — grab's
hook-on and special buckets
NORTHWEST crawler and truck-mounted cranes and shovels
LOCOMOTIVES — Diesel & Diesel Electric
New and Used Equipment
H. KLEINHANS CO.
Established 1911
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DESIGNERS OF
COMPLETE STEEL PLANTS

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1928 Guardian Building • Detroit 26, Michigan
Telephone: Woodward 3-8706 or
Whitmore Lake 5141

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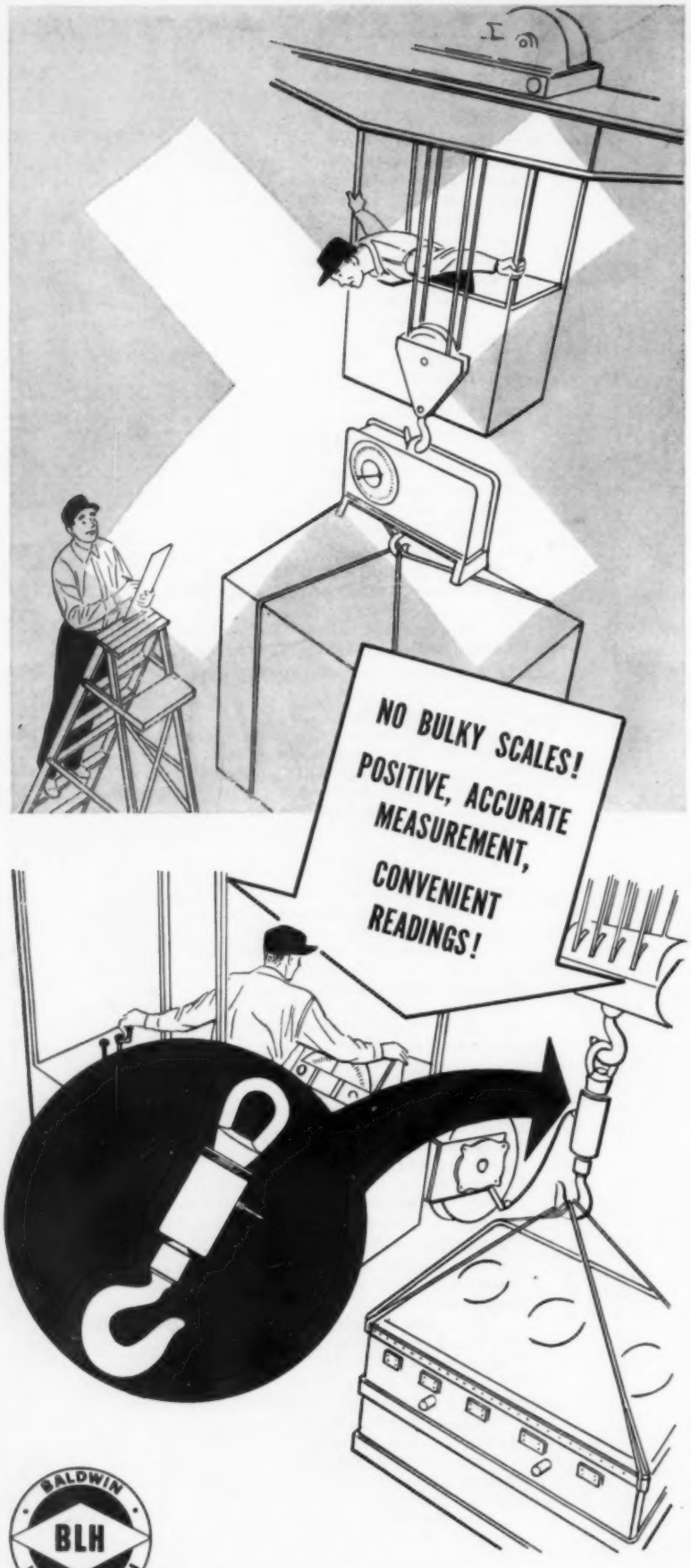

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